

# Auxiliary Propulsion Units

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## UNDERWATER SHIP HUSBANDRY MANUAL

### **CHAPTER 4** **AUXILIARY PROPULSION UNITS**



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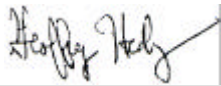
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## S E S R

**ENER S E RE IONS** The following general safety precautions supplement the specific warnings and cautions throughout this chapter. These general precautions are related to the task of removing and replacing the APU. They are precautions that must be understood and applied before and during work on the APU. In addition to the following precautions, personnel must be familiar with and observe safety precautions set forth in the following publications.

- a. Navy Occupational Safety and Health (NAVOSH) *Program Manual for Forces Afloat*, OPNAVINST 5100.19 (series).
- b. *Naval Ships' Technical Manual* (NSTM).
- c. Technical/operating manuals for equipment.
- d. *U.S. Navy Diving Manual*, Volume I, NAVSEA 0944-LP-001-9010.

**N R**

Do not repair or adjust energized equipment alone. The presence of a qualified individual capable of rendering aid is required. Always protect against grounding hazards and make adjustments with one hand free and clear of equipment. Be aware that even after equipment has been de-energized, dangerous electrical hazards can exist due to capacitors retaining electrical charges. Circuits must be grounded and capacitors discharged.

**E**

Make certain electrical test equipment is in good condition and personnel are familiar with its safe operation. Handheld test equipment must be grounded, if possible, to prevent shock injury. Since some types of equipment cannot be grounded, avoid holding them to prevent injury.

**E**

Remain clear of equipment in motion. A safety watch shall be posted if equipment requires adjustment while in motion. The safety watch shall have full view of operations and immediate access to controls that can stop the equipment. If at any time the auxiliary propulsion unit appears to be moving out of control, stop equipment immediately.

**S I**

Limit switches and interlocks are provided to protect personnel and equipment. They should not be overridden or modified except by an authorized person. Do not depend solely upon limit switches for protection. Disconnect power at the power distribution source before adjusting limit switches if possible.

Attend to all injuries, however slight, by obtaining first aid or medical attention immediately.

**R**

Personnel working with or near high voltage shall be familiar with approved resuscitation methods. Begin resuscitation immediately if someone is injured and stops breathing. A delay could cost the victim's life. Resuscitation procedures shall be posted where electrical hazards exist.

**R**

Relative motion is the movement of two or more objects in relation to each other. This poses unique hazards to divers. A common example is a nest of ships swaying and bouncing against each other due to wind and wave action. This motion would easily crush a diver caught between the two ships. To reduce the hazards of relative motion and to simplify the



task, suspend the work platform and rigging from fittings on the ship.

**RNIN S N IONS** Specific warnings and cautions appearing in this chapter are summarized below for emphasis and review. The page number where each warning or caution appears is given in parentheses following the warning or caution.

### **RNIN S**

Rotation of propellers or operation of underwater electrical equipment while divers are in the vicinity can cause serious injury or death. Ensure that ship's equipment, including the APU system, is de-energized and tagged out as required by the *U.S. Navy Diving Manual* prior to beginning underwater operations (page 4-13).

The APU motor weighs approximately 6400 lbs. when assembled. Take special care when moving or lifting it (page 4-13).

### **IONS**

Tools and material inadvertently left at the job site can generate unacceptable noise and possibly cause severe damage to shipboard components. All tools and materials brought to the underwater job site shall be accounted for and removed at the completion of the job. Locally generated work packages shall ensure that a general tool and material log sheet is prepared and maintained during all UWSH operations. (page 4-8).

Do not lose the 0.625-inch square by 7-inch long APU propeller shaft key or the 3/4-inch long 3/8-16 UNC socket head cap screw for the propeller installation. Both items are packed in one of the shipping crates (page 4-13).

Before turning the propeller, spray water through the forward and after vent holes in the motor housing until a good stream of water flows from the drain holes. This will provide lubrication and prevent damage to the rubber sleeve bearings (page 4-14).

Failure to install the Nyloc cap screw may cause loss of the propeller during operation (page 4-14).

The external surface of the support column must be free of burrs to ensure proper extending and retracting operation. To prevent damage to the support column, ensure that the soft liners in the top and bottom clamps of the support column fixture are in place ([Figure 4-4](#)) (page 4-15).

To ensure that the APU is maintained in a level attitude during removal, it is essential that the forward nylon sling be positioned 18 3/4 inches forward of the support column centerline and that the after sling be positioned 10 3/4 inches aft of the support column centerline (page 4-15).

A strain on the electrical cables can result in damage to the cables and/or equipment. When lowering the APU motor, ensure that a strain is not

placed on the electrical cables (page 4-15).

Ensure 10 inch DC plug (included in the kit) is brought into the cofferdam prior to commencing cable replacement. The DC plug provides a means of emergency support column seal if required (page 4-21).

Water contacting the electrical cables can damage insulation and prevent proper electrical connection. Secondary seal temporary sealing caps will ensure water does not penetrate through any break in the secondary seal studs epoxy when the cable assembly is passed from the cofferdam to the surface (page 4-21).

Seal pressure must be maintained at 120-150 psi. Observe the seal hose assembly gauge for several minutes with the

valve shut and the SCUBA bottle inflation hose disconnected to confirm that the closure plug seal is not leaking (page 4-24).

Water contacting the electrical cables can damage insulation and prevent proper electrical connection (page 4-25).

Circulating water is necessary for proper motor cooling. Verify that the 18 vent and drain holes are unplugged before the APU motor is lowered into the water (page 4-26).

Improper alignment of the flange surfaces could dislodge the O-ring and prevent a proper seal when the flange nuts are tightened. Ensure that O-ring 2-448 has not been dislodged (page 4-28).

## CHAPTER 4 AUXILIARY PROPULSION UNITS

### SECTION 1 INTRODUCTION

#### 4-1.1 PURPOSE.

This chapter describes the Naval Sea Systems Command (NAVSEA) approved procedures for waterborne problem identification and replacement of motors and electrical cables for Auxiliary Propulsion Units (APUs) on FFG 7 Class ships. These procedures provide detailed, standardized instructions for APU system problem identification, cofferdam installation and removal, APU motor removal and replacement, and electrical cable removal and replacement. A listing of required tools, materials, and equipment is included.

#### 4-1.2 SCOPE.

These procedures have been used and validated at various Navy ship maintenance facilities. The proper use of these procedures will result in a permanent repair and eliminate the need for emergency or unscheduled dry docking. Currently, APUs are installed only in FFG 7 class ships. Similar units, Secondary Propulsion Motors (SPMs), are installed in SSN and SSBN class submarines. (SPMs are not discussed in the chapter. Refer to Chapter 8 of the *Underwater Ship Husbandry Manual* for waterborne SPM maintenance.)

#### 4-1.3 REFERENCE DOCUMENTS.

This chapter refers to the following documents to assist in APU problem identification, APU motor replacement, and APU electrical cable replacement. These documents must be used for operational planning and be available at the repair site to support operations.

- a. NAVSEA S9237-AD-MMA-010, *Technical Manual for Description, Operation and Maintenance Instructions, Retractable Auxiliary Propulsion Equipment*

*System*, 15 February 1989, NSN 0910-LP-110-9600.

- b. NAVSEA Drawing PF 109 (FFG 7) 111-5350018 and Parts List 111-PL5350024, SHL PLTG; FR & LONG, FR 93-153. (Drawing provides fabrication and assembly details for APU hull closure plate.)
- c. NAVSEA Drawing PF 109 (FFG 7) 201-5414115, AUX PROP UNIT MCHRY RM ARR FR 100-108. (Drawing shows location and arrangement of APU machinery room.)
- d. Louis Allis Drawing 15S00754-1000, Train & Retract Device, Auxiliary Propulsion System. (Drawing is available in most SIMA technical libraries and details the assembly of the APU system training and retracting device.)
- e. Louis Allis Drawing 15S00337-2000, Motor - Alternating Current, Auxiliary Propulsion. (Drawing is available in most SIMA technical libraries and details the assembly of the APU motor.)
- f. NAVSEA S9086-KC-STM-010/CH-300, *Naval Ships' Technical Manual*, Chapter 300, "Electrical Plant - General," 1 February 1996.

#### 4-1.4 APU SYSTEM DESCRIPTION.

The auxiliary propulsion system in FFG 7 class ships consists of two APUs, one on each side of the keel between frames 100 and 108 ([Figure 4-1](#)). Each APU comprises three major components: the APU motor, the training and retracting device (TRD), and the controls. The APU motor and the TRD are shown in [Figure](#)

4-2. The controls are located within the ship and are discussed in [reference a](#). The APU motor drives a propeller which operates in a Kort Nozzle attached to the motor housing. The TRD consists of a support column and two motors—a training motor for rotating the unit and a retracting motor for raising and lowering the APU motor. When not in use, the APU motor is retracted to the stored position within the hull. The opening in the shell plating is faired by a curved closure plate attached to the underside of the APU motor. (See [reference b](#).) Electrical interlocks are designed to prevent the APU motor from operating or rotating when it is not in the fully extended position. These interlocks can fail and allow the APU motor to rotate, which can in turn cause hull damage when the APU motor is extended or retracted.

#### 4-1.5 PROBLEM IDENTIFICATION.

Two types of problems generally occur in the APU system: an electrical (typically grounding of one or more phases of the three-phase 440VAC system) or a mechanical failure (typically physical damage from a submerged object or internal APU motor bearing wear). Ship's Force should be capable of electrical fault diagnosis as detailed below. Ship's Force should also monitor APU performance to help diagnose mechanical problems as detailed in paragraph 4-1.5.2. Obviously, complete diagnosis of mechanical problems requires divers to perform the inspections detailed below.

**4-1.5.1 Electrical Problems.** The most common APU electrical problem is grounding of one or more phases of the three-phase, 440VAC electrical system. When a grounding problem is suspected, or a regular inspection catches an electrical problem early on, Ship's Force should megger check each phase of the system at the APU machinery room power distribution panel using a 500-VDC megger. Correct each electrical insulation resistance measurement to the equivalent 25°C value using the nomograph in [Appendix A](#) (an example correction is provided in [Figure A-2](#)). The corrected insulation resistance must be equal

to or greater than 3 megohms. FFG 7 Class Advisory No. 02-97 revised MRC 13-4NMB-N to require a minimum of 10 Megohms insulation resistance in each phase of the APU motor 440 VAC circuit. 10 Megohms should be achievable, but 3 Megohms is an acceptable minimum because of possible moisture entrapment from waterborne cable replacement. If the electrical insulation resistance is less than 3 megohms, Ship's Force must disassemble the brush and slip ring assemblies from the training and retracting device to expose the secondary seal assembly, as shown in [Figure 4-3](#). To disassemble the training and retracting device:

- a. Complete steps a through g of [reference a](#), paragraph 6-5.9.1. Remove and set aside the complete brush holder assembly after completing step g above.
- b. Follow step b and the first sentence of step c of [reference a](#), paragraph 6-5.9.2, to loosen the slip ring assembly.
- c. Once the slip ring assembly is loose, modify the procedure of reference a, paragraph 6-5.9.2 by removing the entire slip ring mounting plate with attached cables as a unit. Leave the nine (9) electrical cables attached to the bottom of the slip ring mounting plate and disconnect the three (3) lead terminals (item 46 of [reference d](#)) from the three (3) secondary seal studs (item 48 of [reference d](#)) at the secondary seal disk (item 47 of [reference d](#), see [Figure 4-3](#)). It is often necessary to rotate the slip ring mounting plate to untwist the electrical cables and gain access to the three lead terminals.

**4-1.5.1.1** Once the brush and slip ring assemblies are removed and access to the three (3) secondary seal studs is obtained, megger check each phase at the secondary seal studs. If the corrected electrical insulation resistance readings are equal to or greater

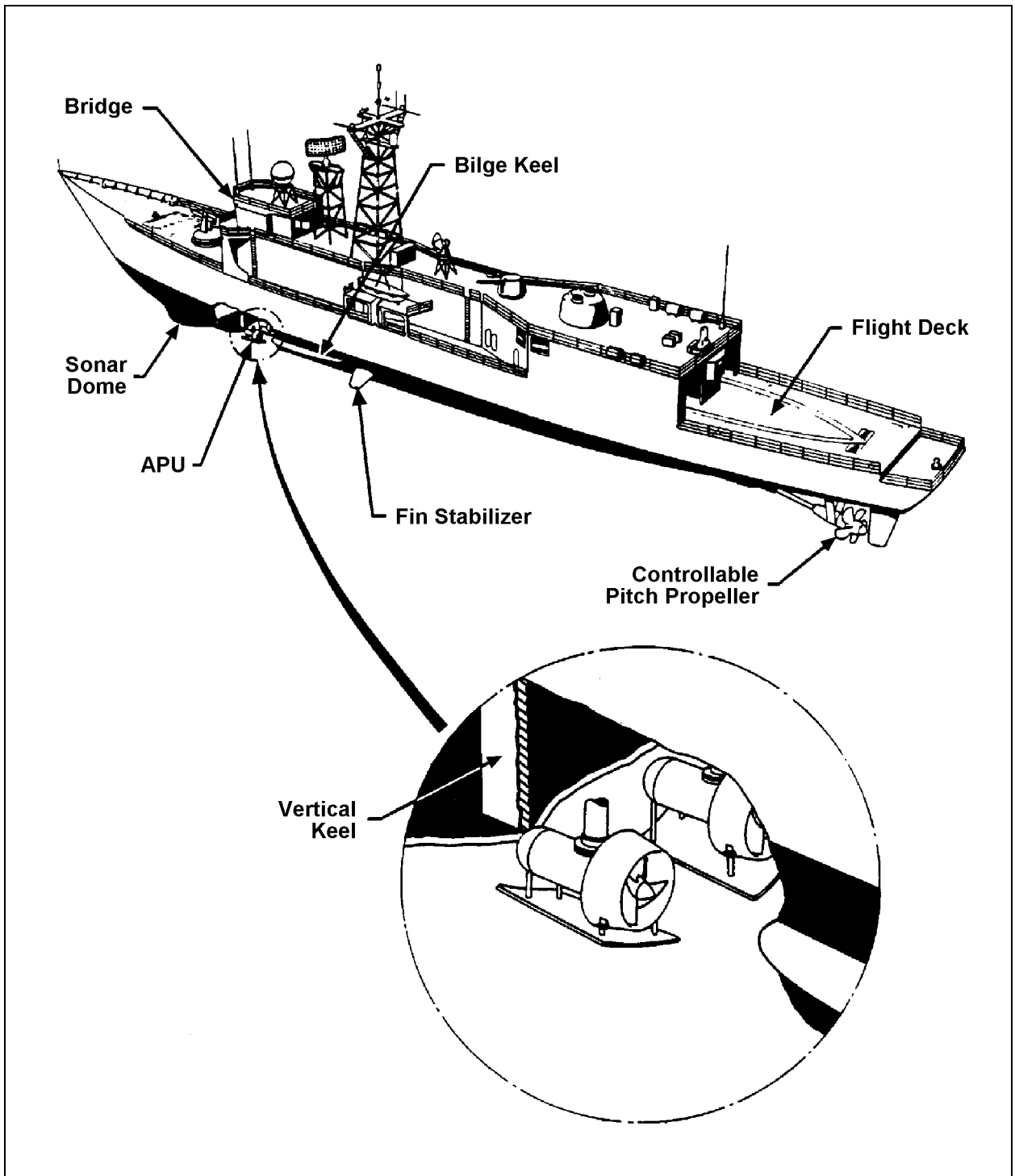


Figure 4-1. Location of APU in FFG 7 Class Ships.

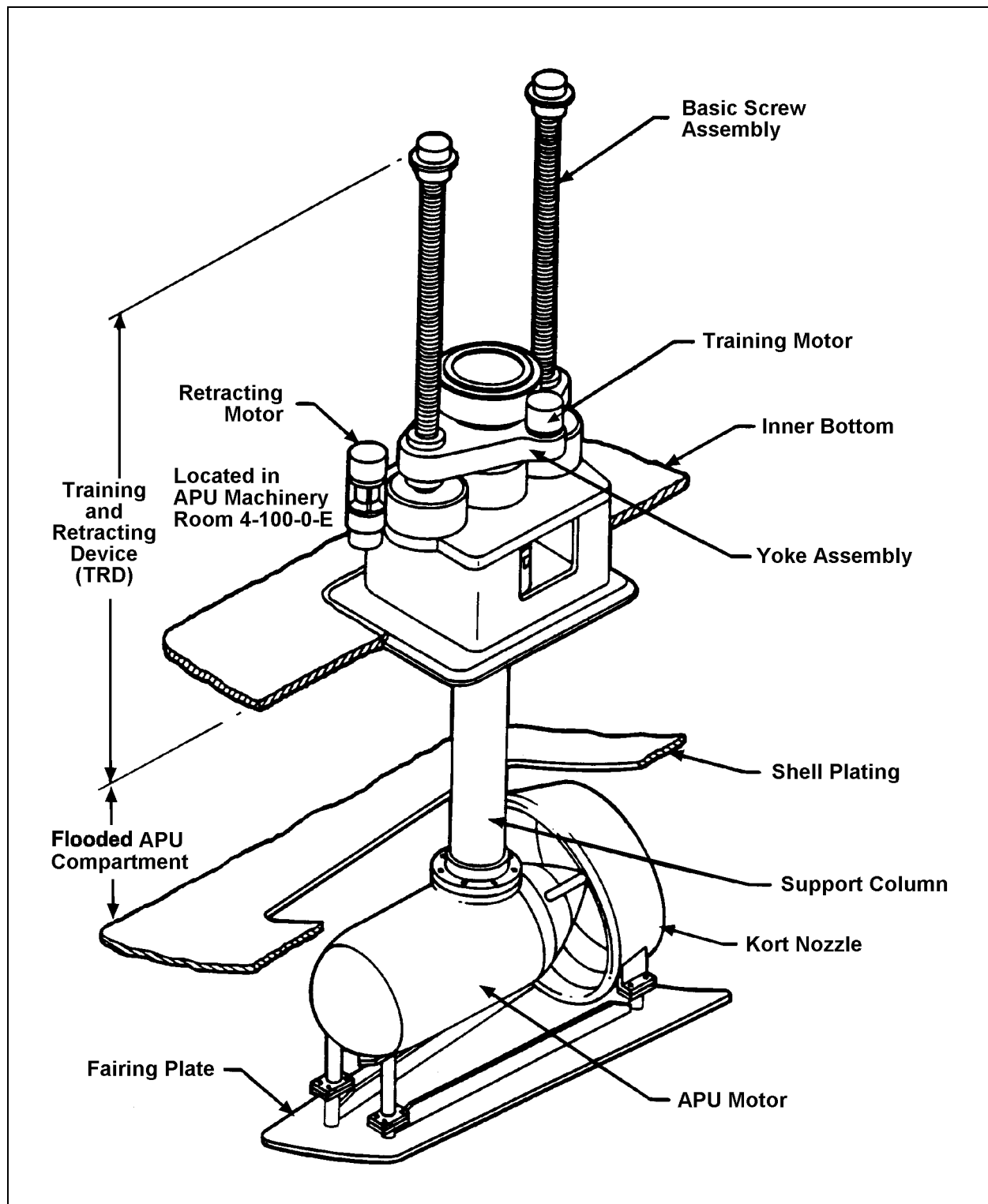


Figure 4-2. APU Components.

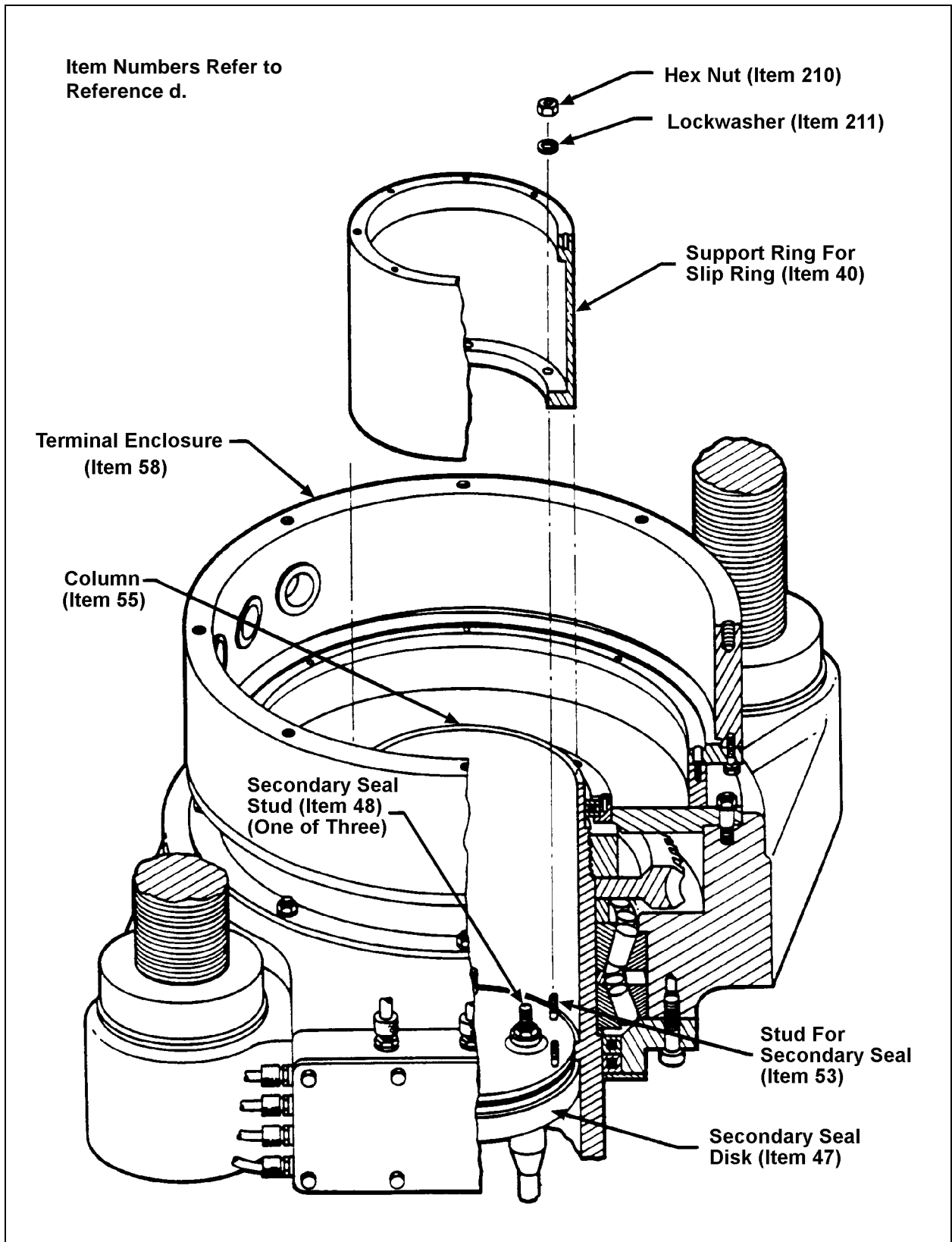


Figure 4-3. Training and Retracting Device with Brush and Slip Ring Assemblies Removed.

than 3 megohms, the electrical problem is somewhere in the brush or slip ring assemblies. Ship's Force should follow the instructions in [references a and d](#) to further disassemble and repair the brush and slip ring assemblies. If the corrected electrical insulation resistance readings are less than 3 megohms, the electrical problem is in the secondary seal assembly or the lead cables from the APU motor to the secondary seal. Diver assistance will be required to install the cofferdam and remove the APU motor, lead electrical cables, and secondary seal as described in [section 2](#) of this chapter. [Appendix B](#) provides NAVSEA drawings that detail fabrication of improved design replacement secondary seal studs and secondary seal disk as required. The drawings in [Appendix B](#) also provide direct procurement sources for replacement of the lead electrical cables (item 52, [reference d](#)).

**4-1.5.2 Mechanical Problems.** High motor amperage (greater than 800 amperes) or an increase in noise or vibration during APU motor operation are signs of mechanical damage or bearing wear problems. In these cases, Ship's Force should request diver inspection of the APU system. Loud metal-to-metal contact noise during retraction or extension of the APU may indicate APU motor misalignment or improperly set limit switches. Again, Ship's Force should request diver inspection.

**4-1.5.2.1 Diver APU Inspection.** Record inspection observations and measurements on the [Auxiliary Propulsion Unit Inspection Data form, NAVSEA 4730/8](#) (see [Appendix C](#)).

**4-1.5.2.1.1 Damage Description Requirements.** Include the exact location of all damage or flaws. Description must include as a minimum:

- a. Distance and direction (port/starboard, forward/aft) from an obvious reference.
- b. Length, maximum width, and orientation of all cracks. If the crack is on or near a weld seam, include closest weld

seam information, that is, direction of the crack with respect to the weld (perpendicular or parallel) and proximity to the weld (center of the weld or base metal).

- c. Total area affected, including the diameter and depth of any pitting. Include both the maximum and average pit size.

#### 4-1.5.2.1.2 Inspection Procedure.

##### NOTE

A level 2 inspection of the APU must be conducted with the unit in both the retracted and the deployed position. Begin the inspection with the unit in the deployed position.

- a. Inspect the support column flange for the presence of all fasteners.
- b. Verify that the small gap between the support column flange and the motor flange is not more than 1/2 inch deep.
- c. Inspect the motor-to-fairing plate legs for any apparent damage and for the presence of all flange nuts and bolts (and lock wires, if used).
- d. Inspect the fairing plate for any structural damage.
- e. Inspect and report the Fouling Rating (FR) and the Paint Deterioration Rating (PDR) of the fairing plate.
- f. Inspect the Kort nozzle for structural damage.
  - (1) Verify that the six drain holes of the nozzle (three in the top and three in the bottom) are clear.
  - (2) Inspect and report the FR of the Kort nozzle.



## g. Inspect the propeller.

- (1) Inspect the propeller hub for fouled wire, rope, or other foreign material. Propellers may become fouled by fiber or wire. Fiber such as fish net or manila line is usually removed without difficulty. If removal of the material will be time consuming, make the appropriate report and arrangements for follow-on removal.
- (2) Push the propeller forward toward the motor housing. Measure and record the clearance between the APU motor housing and the propeller hub. Pull the propeller aft away from the motor housing. Measure and record the clearance between the APU motor housing and the propeller hub. The difference between the two measurements (the total fore and aft movement of the propeller shaft) must not exceed 1/8 (0.125) inch.
- (3) Measure and record with a feeler gauge the clearance between each blade tip and the Kort nozzle. Blade tip clearance must be between 0.040 inch (minimum) and 0.185 inch (maximum).
- (4) Report the overall physical appearance and FR of each blade. Inspect the leading and trailing edges for nicks, curls, dents, flay spots, cracks, and other damage.
- (5) Measure and record the extent of all damage.

## h. Inspect and record the FR of the APU motor.

- i. If any discrepancies are found, make an appropriate report and arrangements for follow-on repair.

**NOTE**

Verify with Ship's Force that the bench mark is at the "zero" position.

- j. Retract the APU motor until the fairing plate is 6 inches below the hull opening. Inspect to determine if the motor is out of rotational alignment. If so, have Ship's Force correct the alignment, change the bench mark inside the APU machinery room in accordance with paragraph 8-4.1 of [reference a](#), and adjust the travel limit switches in accordance with paragraph 8-4.2 of [reference a](#).
- k. Retract the APU motor fully.
  - (1) Ensure that the APU is properly housed and flush with the adjacent hull.
  - (2) Verify that the gap between the hull opening and the fairing plate is uniform all around. The allowable gap is 1 inch  $\pm$  1/4 inch.
  - (3) Inspect the fairness of the APU fairing plate with the outer shell plating. Measure and record the projection and depression of the forward and after edges of the fairing. Take a minimum of three readings (port, center, and starboard) on each edge.
    - (a) The forward edge of the plate should be flush or recessed no more than 1/4 inch from the surface of the outer shell plating.
    - (b) The after edge should be flush or protruding no more

than 1/4 inch from the surface of the outer shell plating.

#### 4-1.5.2.2 Interpretation of APU Inspection Results.

- a. Obvious physical damage must be evaluated for repair as required.
- b. Missing or loose support column flange or fairing plate-to-motor fasteners must be replaced or tightened. Torque requirements for these fasteners are provided in [section 2](#) of this chapter.
- c. If the total fore and aft movement of the propeller shaft is more than 1/8 (0.125) inch, the APU motor thrust bearings must be replaced.
- d. If any propeller tip-to-Kort nozzle clearance is less than 0.040 inch or more than 0.185 inch, the APU motor sleeve bearings must be replaced.
- e. If the APU fairing plate is rotationally misaligned at the existing ship's internal APU machinery benchmark, the benchmark must be corrected and alignment limit switches reset.
- f. If the APU fairing plate is protruded or recessed more than the allowed 1/4 inch, the APU motor should be removed and brought to the surface so that the forward/aft APU motor leg shim thickness can be adjusted.

#### 4-1.6 PLANNING AND PREPARATION.

##### CAUTION

Tools and material inadvertently left at the job site can generate unacceptable noise and possibly cause severe damage to shipboard components. All tools and materials brought to the underwater job site shall be

accounted for and removed at the completion of the job. Locally generated work packages shall ensure that a general tool and material log sheet is prepared and maintained during all UWSH operations.

**4-1.6.1** Planning and preparation are essential to the successful completion of any underwater ship husbandry task. The following items are unique to APU repair or replacement operations:

- a. Has the real problem with the APU system been identified as detailed in [section 4-1.5](#)? Perhaps more than one problem exists. It's better to work with Ship's Force to identify all system electrical and mechanical problems early, so that your request for non-local equipment and replacement parts and repair assets will be as complete as possible.
- b. One or both of the following APU system problems should exist prior to mobilizing repair assets to perform a waterborne repair:
  - (1) Electrical megger checks at the secondary seal studs have confirmed that a system ground or electrical discontinuity exists in or below the secondary seal disk. The APU motor must be disconnected from electrical cables at the support column flange in order to further isolate the problem to the motor or the cables.
  - (2) Mechanical damage or APU motor bearing failure has been confirmed by diver inspection as detailed in [section 4-1.5](#). The APU motor/fairing plate must be removed, refurbished, and replaced.

- c. The ship should be moored with the damaged APU toward the pier. A minimum water depth below the keel of 10 feet is required, with 20 feet desirable.
- d. Schedule four work shifts of 8 hours each to complete a typical waterborne APU motor replacement. Add one 8-hour shift if the electrical cables are to be replaced. For planning purposes the schedule estimate breaks down as:
  - (1) One day for installing the APU cofferdam.
  - (2) One day for rigging the support column fixture, disconnecting the APU motor, and bringing the APU motor to the surface.
  - (3) One day for installing a new motor and conducting electrical checks.
  - (4) One day to remove the cofferdam.
  - (5) One additional day if electrical cable removal and replacement is required.

This estimated schedule has considerable margin for contingencies and an inexperienced repair team. Progress against any schedule is contingent upon lack of interruptions from ship movements or sonar operations.

- e. Crane service will be required during the operation to handle the APU cofferdam (1500 lbs. dry) and the APU motor with fairing plate attached (7800 lbs. dry).
- f. Communication is essential between personnel in the APU machinery room

and the dive station during electrical cable replacement or cable megger checks.

- g. [Appendix D](#) provides NAVSEA drawings that detail the equipment included in the FFG 7 APU kit available from NAVSEA 00C5. In addition to the basic kit, NAVSEA Drawing [6697724](#) details the use of an alignment fixture to target the welding of a new fairing plate so that when it is installed on the APU motor legs the fairing plate will align with the hull opening. This alignment fixture should be requested if fairing plate damage will require replacement. [Table 4-1](#) details the equipment, tools, and material that must be provided by the repair activity.
- h. The APU motor, Kort nozzle, and propeller usually come disassembled. Assembly of the APU should be done in accordance with [paragraph 4-2.2](#) of this chapter. It is best to arrange for assembly in a shop with an overhead traveling gantry that can lift the Kort nozzle for alignment and installation on the APU motor. In fact, transfer of the fairing plate (see item i below) is also much easier and safer with the use of an overhead gantry.
- i. Replacement of the APU motor requires the transfer of the fairing plate from the old motor to the new motor. This provides the opportunity to correct any excessive protrusion or depression of the fairing plate noted during the diver inspection ([paragraph 4-1.5.2.1](#)) by changing the shims between the APU motor legs and the fairing plate legs. Shims of the required thickness should be manufactured in accordance with [reference b](#), sheet 6A, part numbers 303 and 306.

**Table 4-1. Equipment, Material, and Tools to be Provided by the Repair Activity.**

<b>Item</b>	<b>Purpose</b>
Standard mechanic's tool set	Cofferdam installation and removal, bolt/nut removal and installation
500 VDC megohmmeter	Electrical insulation resistance checks
Multimeter	Electrical continuity checks
Dry nitrogen, large bottle	Drying electrical connections
Crane, 10 ton	Rigging cofferdam and APU motor
Spirit level, 7-inch	Level APU motor to align with support column flange
Walkie-talkie radios or sound-powered phones	Communication with dive station and APU machinery room
Ship service air connection with hose barb fitting for 3/4-inch ID, 100-foot long cofferdam air hose supplied with cofferdam	Cofferdam blowdown
Emery cloth, 00	Clean electrical connections
Electrical cable tags (tie-wraps)	Mark T1, T2, and T3 electrical cables
Cofferdam sealing material (Bintsuke or Ductseal)	Seal minor leaks in the cofferdam
Dunnage	Support APU motor and fairing plate on the pier
SCUBA bottle with BC inflation whip	Inflate secondary seal closure plug
O-ring, BUNA-N, 2-445-N674-70 NSN 5330-00-166-1059	Secondary seal disk
O-ring, BUNA-N, 2-448-N674-70 NSN 5330-00-876-5666	APU motor-to-support column flange
Monel bolts, 1/2-13 UNC, 3 1/4-inch long Part number MS35311-120 NSN 5305-00-226-9197, 8 required	Forward APU motor-to-fairing plate attachment
Monel self-locking nuts, 1/2-13 UNC Part number MS17828-8C NSN 5310-01-399-3413, 8 required	Forward APU motor-to-fairing plate attachment
Monel bolts, 7/8-9 UNC, 4-inch long Part number MS35311-217 NSN 5305-00-226-9235, 4 required	Aft APU motor-to-fairing plate attachment
Monel self-locking nuts, 7/8-9 UNC Part number MS17828-14C NSN 5310-01-202-3432, 4 required	Aft APU motor-to-fairing plate attachment
Monel self-locking nuts, 1-8 UNC Part number MS17828-16C NSN 5310-01-244-5012, 8 required	APU motor-to-support column flange (normally supplied with replacement APU motor, but spares are desirable)

**Table 4-1. Equipment, Material, and Tools to be Provided by the Repair Activity.**

<b>Item</b>	<b>Purpose</b>
Shim stock in accordance with <a href="#">reference b</a> , sheet 6A, part numbers 303 and 306	Re-shim fairing plate
Thread lubricant - Molykote P37 Dow Corning Product #15255 Item #2397421 for 1.1 lb. can Product information (517) 496-6000	Lubricate fasteners
Torque wrenches 36 ft.-lbs.  133 ft.-lbs. 48 ft.-lbs. 135 ft.-lbs. 150 ft.-lbs.	1/2-inch fasteners on forward fairing legs (Figure 4-8) 7/8-inch fasteners on aft fairing legs (Figure 4-8) Support ring for slip ring fasteners (step 4-2.5.43) Kort nozzle fasteners (step 4-2.2g) APU motor flange stud stop nuts (step 4-2.6.15)
C-clamps (2)	Hold top hat in place while bolting support column flange

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## SECTION 2 APU SYSTEM REPAIR AND REPLACEMENT PROCEDURES

### WARNING

Rotation of propellers or operation of underwater electrical equipment while divers are in the vicinity can cause serious injury or death. Ensure that ship's equipment, including the APU system, is de-energized and tagged out as required by the *U.S. Navy Diving Manual* prior to beginning underwater operations.

#### 4-2.1 PROCEDURES PROVIDED.

This section provides detailed procedures for:

- a. APU motor assembly
- b. APU cofferdam installation
- c. APU motor removal
- d. Electric cable replacement
- e. APU motor replacement

#### 4-2.2 APU MOTOR ASSEMBLY.

### WARNING

The APU motor weighs approximately 6400 lbs. when assembled. Take special care when moving or lifting it.

### CAUTION

Do not lose the 0.625-inch square by 7-inch long APU pro-

peller shaft key or the 3/4-inch long 3/8-16 UNC socket head cap screw for the propeller installation. Both items are packed in one of the shipping crates.

- a. The APU is delivered from the OEM in three separate crates: the Kort nozzle, the propeller, and the motor. Each component requires careful uncrating and assembly prior to being deployed. The APU should be assembled in a shop with an overhead traveling gantry that can lift the Kort nozzle to align it for fit-up to the APU motor.
- b. In order to assemble the Kort nozzle onto the APU, the motor must be elevated approximately 30 inches off the floor. Care must be taken to ensure that the motor remains level while elevated to facilitate installing the Kort nozzle.
- c. Remove all of the crating on the sides of the motor. Leave the motor on its shipping cradle. With a fork lift, lift the motor by the base of its crate and place dunnage under the crate to elevate the motor 30 inches off the floor of the shop. Be sure that the motor is positioned under the crane to allow for maneuvering the Kort nozzle onto the motor.
- d. With the APU motor securely in position, clean and lubricate the Kort nozzle flange on the motor and the mating surface of the Kort nozzle.

### NOTE

It is very important that these mating surfaces are thoroughly cleaned and lubricated prior to assembly. Even small pieces of

dirt or other foreign material will make assembly extremely difficult.

- e. Using the crane, lift the Kort nozzle with the motor flange facing forward.
- f. Elevate and align the Kort nozzle to the height of the motor and proceed to drive the Kort nozzle onto the APU motor. Care must be exercised in doing this step to prevent moving the motor on its cradle.
- g. When the Kort nozzle is fully seated on the motor, fasten the Kort nozzle to the motor using the eight 3/4-10 UNC hex head cap screws and 3/4-inch lock washers. Torque to 135 ft.-lbs.

### CAUTION

Before turning the propeller, spray water through the forward and after vent holes in the motor housing until a good stream of water flows from the drain holes. This will provide lubrication and prevent damage to the rubber sleeve bearings.

- h. Install the 0.625-inch square by 7-inch long propeller shaft key into the propeller shaft. Lift and install the propeller onto the shaft, ensuring that the key is aligned with the propeller keyway.
- i. Install the conical propeller nut and tighten using the special propeller nut tool shown in NAVSEA Drawing [6699603](#) provided in [Appendix D](#). Continue to tighten the propeller nut until the clearance between the tip of each propeller blade is between 0.040 and 0.185 inch.
- j. When the propeller is properly seated, center punch through one hole in the propeller nut to mark the location in the

after face of the propeller hub for drilling and tapping the hole for the propeller nut locking screw.

### CAUTION

Failure to install the Nyloc cap screw may cause loss of the propeller during operation.

- k. Remove the propeller nut, then drill and tap a 3/8-16 UNC hole at the marked location. Reinstall the propeller nut and tighten until the 3/8-16 UNC Nyloc cap screw can be installed to lock the propeller nut in place.
- l. The APU motor is now ready to be mounted onto the fairing plate after the damaged motor assembly has been removed. The fairing plate transfer is best accomplished in the shop using the overhead traveling or gantry crane to position the assembled motor onto the fairing plate which has been braced in a level position using dunnage.

## 4-2.3 COFFERDAM INSTALLATION PROCEDURES.

Removal of the APU or electrical cables requires the use of a cofferdam. Procedures for the rigging, installation, and removal of the cofferdam are covered in NAVSEA Drawing [6699592](#), APU Removal Rigging Plan, provided in [Appendix D](#). It is preferred that the ship be berthed with the damaged APU toward the pier.

### NOTE

Section 16-6.6.8 of the [Cofferdam Manual](#), NAVSEA S0600-AA-PRO-160, requires that with the dewatering system secured, the maximum leakage rate may not exceed 4 inches/hour rise in water level



with the chamber fully dewatered.

**4-2.3.1** Cofferdam alignment fixtures are included in the kit to help the divers with fore and aft alignment of the cofferdam during installation. The alignment fixtures are hand tightened clamps installed on the forward and aft lips of the APU hull opening.

**4-2.3.2** Some FFG 7 Class ships have vent lines installed in the APU machinery room for venting air out of the free-flooding APU motor storage space. Ensure that these vents are shut before attempting cofferdam blowdown.

#### **4-2.4 APU MOTOR REMOVAL PROCEDURES.**

Request Ship's Force to energize the retracting motor and lower the APU all the way to the limit switch. De-energize and tag out the retracting motor.

#### **CAUTION**

The external surface of the support column must be free of burrs to ensure proper extending and retracting operation. To prevent damage to the support column, ensure that the soft liners in the top and bottom clamps of the support column fixture are in place ([Figure 4-4](#)).

**4-2.4.1** Install the support column fixture on the support column with the longer part of the bracket over the forward end of the APU ([Figure 4-4](#)). Use a web-type scuba weight belt to hold the after half of the support column fixture in place while assembling the support column fixture. Ensure the fixture is oriented fore and aft.

**4-2.4.2** Rigging shall be done in accordance with NAVSEA Drawing [6699592](#), APU Removal Rigging Plan, provided in [Appendix D](#).

#### **CAUTION**

To ensure that the APU is maintained in a level attitude during removal, it is essential that the forward nylon sling be positioned 18 3/4 inches forward of the support column centerline and that the after sling be positioned 10 3/4 inches aft of the support column centerline.

**4-2.4.3** Remove all slack from the hoist chains so that they are able to take the weight of the APU motor as the flange bolts are loosened.

**4-2.4.4** Loosen the eight 1-inch stop nuts on the APU motor flange approximately one-half turn until the seal breaks between the support column flange and the APU motor flange, thus permitting the interior of the support column to equalize with the pressure in the cofferdam.

**4-2.4.5** Remove the eight 1-inch stop nuts.

#### **CAUTION**

A strain on the electrical cables can result in damage to the cables and/or equipment. When lowering the APU motor, ensure that a strain is not placed on the electrical cables.

**4-2.4.6** Lower the APU motor no more than 6 inches using the hoists to gain access to the three electrical cable connectors ([Figure 4-5](#)).

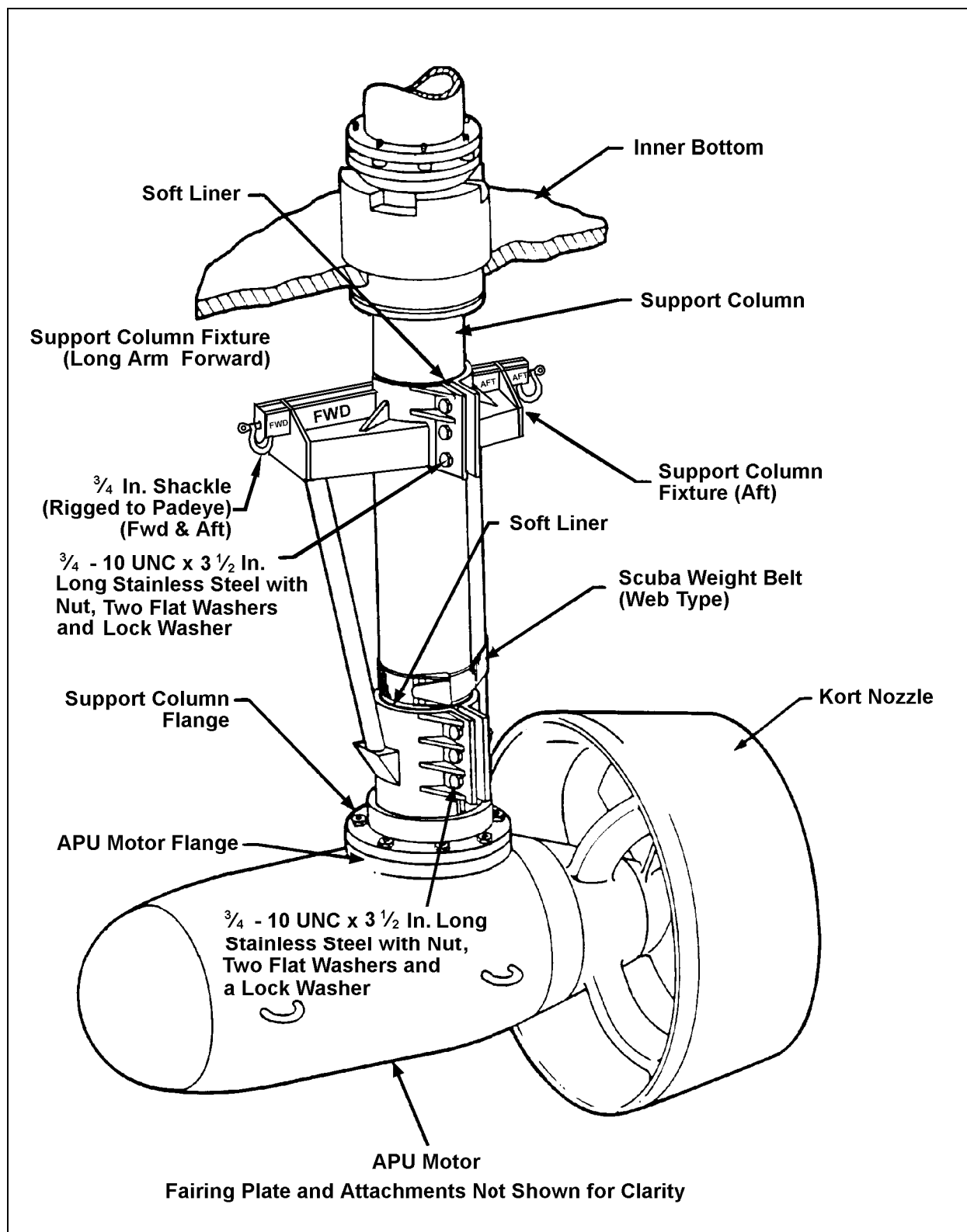
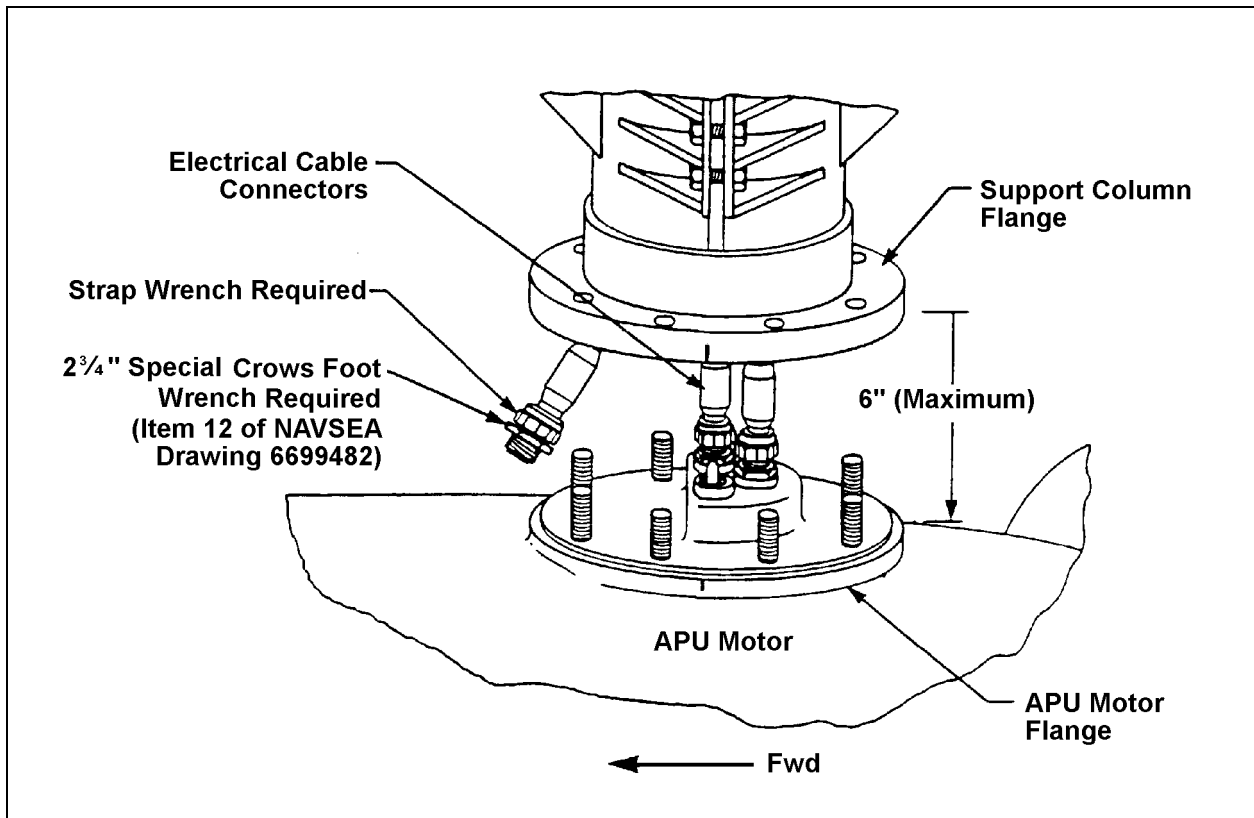


Figure 4-4. Attachment of Support Column Fixture.



**Figure 4-5. Electrical Cable Disconnection.**

**4-2.4.7** Tag or mark the connectors on the electrical cables to correspond to the identifying marks (T1, T2, and T3) on the APU motor electrical terminals.

**4-2.4.8** Disconnect the three electrical cables. Back off on the 2 3/4-inch lock nuts, then remove the cast body connector using a strap wrench. The cast body connector is supposed to rotate on the electrical cable to allow for loosening the connector from the motor. Often the cast body connector will stick to the rubber cable jacket. Silicon spray is provided in the APU kit to help loosen the rubber from the connector.

**4-2.4.9** Lower the APU motor approximately 1 foot using the hoists.

**4-2.4.10** Inspect the electrical cables and the inside of the support column for moisture.

**4-2.4.11** Circulate dry nitrogen inside the support column to eliminate moisture. Dry the

electrical cables, APU motor connectors and special seal plugs. Install the special seal plugs on the APU motor connectors and the special sealing caps on the electrical cable connectors (Figure 4-6). Install the top hat cover and gasket on the bottom of the support column. Ensure that the valve assembly (item 3 of NAVSEA Drawing 6699494 in Appendix D) is installed in the threaded hole in the top hat cover (Figure 4-7).

**4-2.4.12** Remove the APU motor to the pier in accordance with NAVSEA Drawing 6699592.

**4-2.4.13** Remove the special sealing plugs from the APU motor electrical connectors.

**4-2.4.14** If the APU motor was removed because of a ground fault detected by Ship's Force somewhere below the secondary seal disk, have Ship's Force megger check the APU motor while on the pier and the electrical cables below the secondary seal. This will assist in isolating the fault to the APU motor,

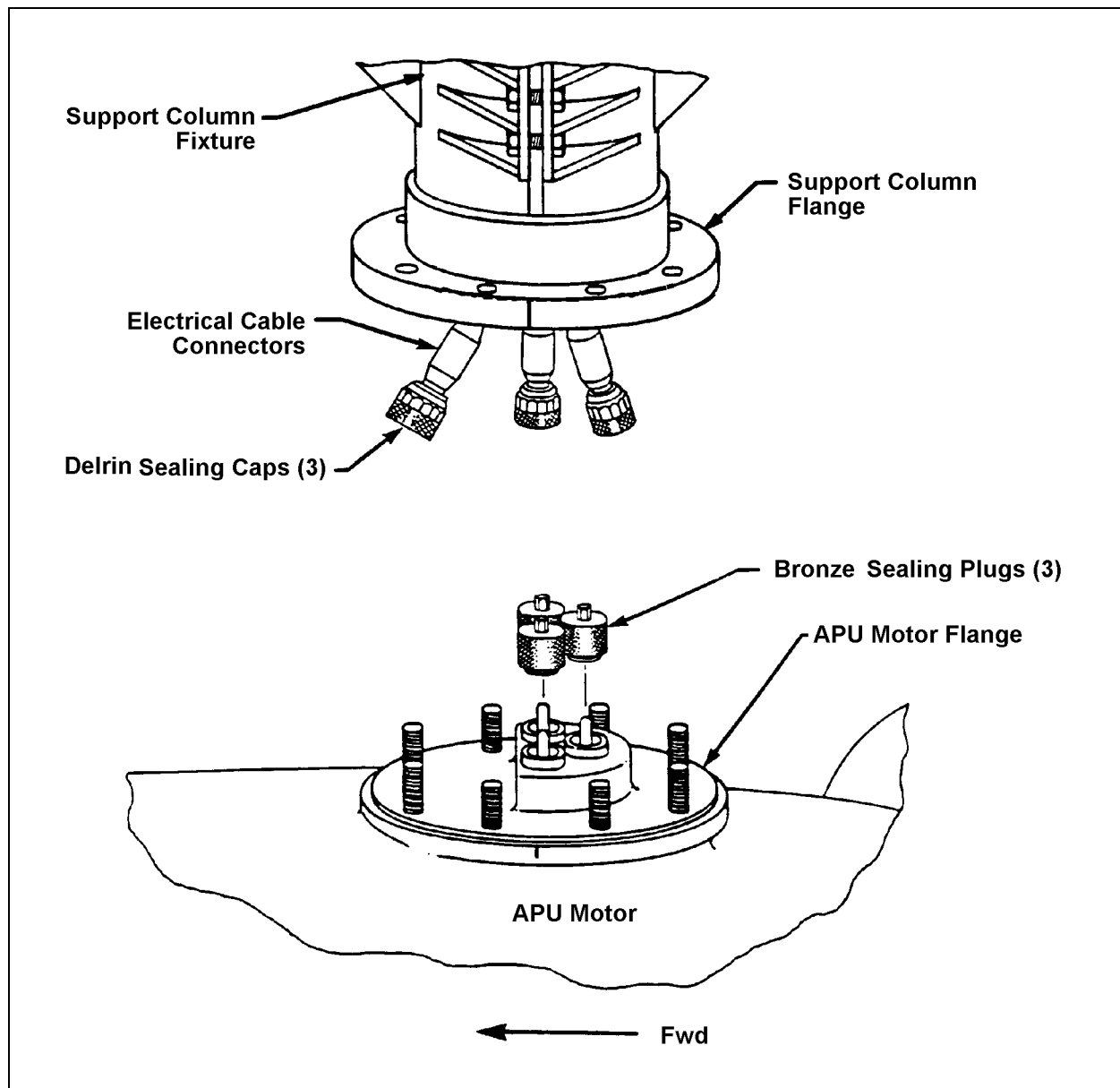


Figure 4-6. Installation of Special Seal Plugs and Caps.

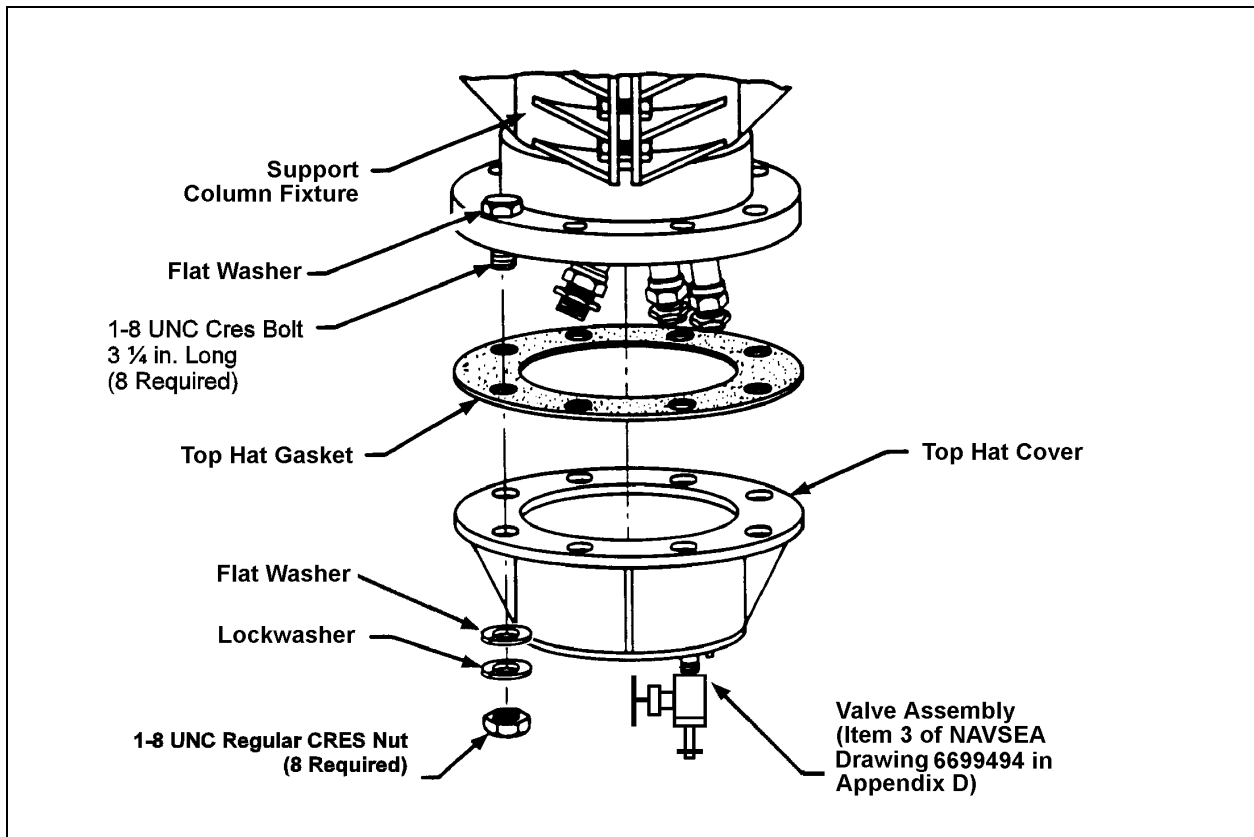


Figure 4-7. Installation of Top Hat Cover and Gasket.

the secondary seal and cables, or both. In addition to these megger checks, voltage surge comparison tests conducted by the repair activity in accordance with paragraph 300-3.5.4 of [reference f](#) may help to identify APU motor electrical problems.

**4-2.4.15** If the APU motor passes the electrical checks and there are no mechanical problems, set the motor aside and proceed with electrical cable replacement in accordance with paragraph 4-2.5. If the motor has mechanical problems or fails the electrical checks, send the motor to the shop where the new motor was assembled for transfer of the fairing plate.

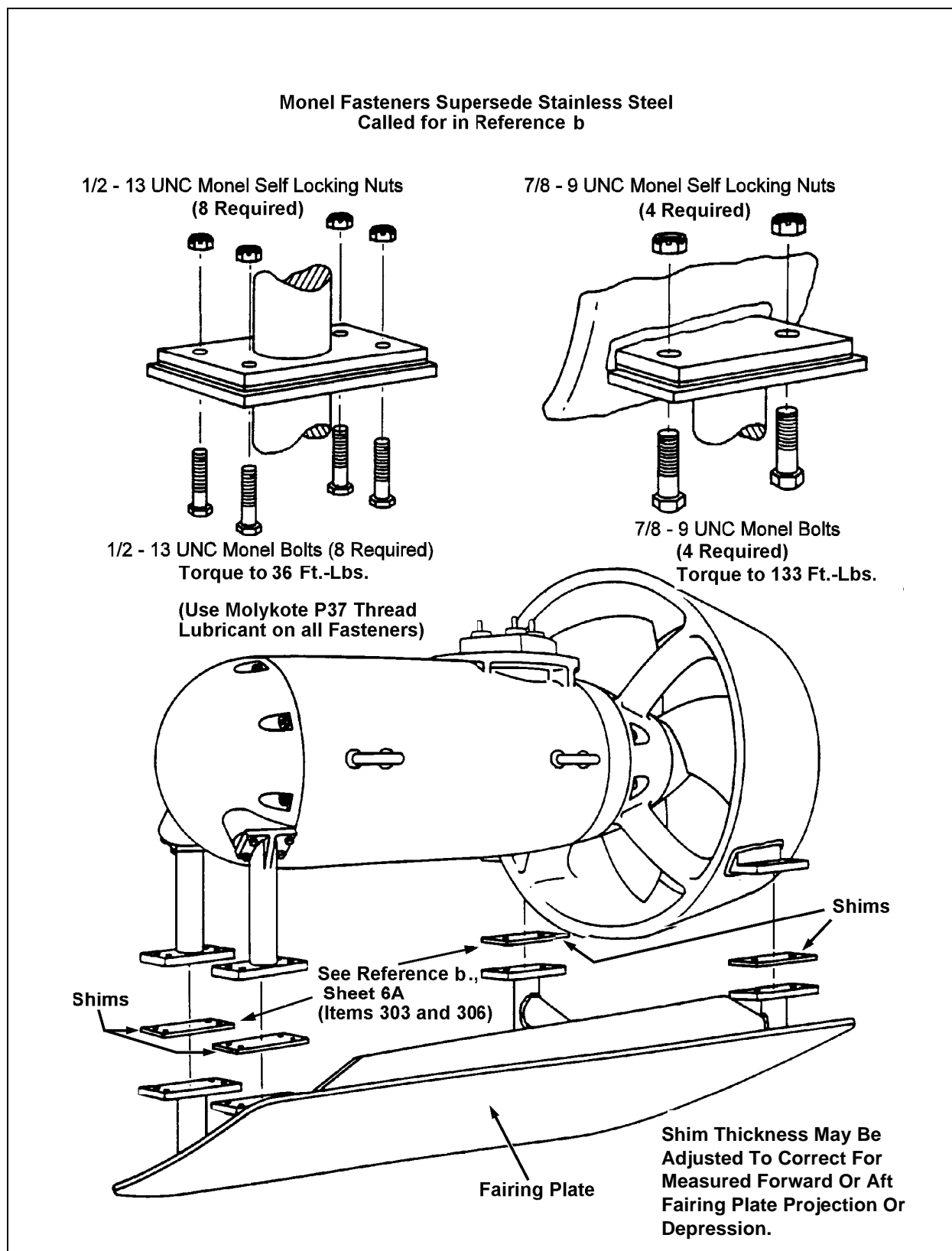
**4-2.4.16** Transfer the APU motor fairing plate in accordance with [Figure 4-8](#). Experience has shown that the APU motor legs and fairing plate legs may spring when the old motor is removed. It is best to first align one fastener

for each of the four mating flanges in a circular fashion around the APU motor/fairing plate assembly. Then proceed around the unit aligning additional fasteners until all fasteners are installed and torqued properly. Experience indicates that it may often take some time working with the assembly to achieve alignment of all the fastener holes.

#### 4-2.5 ELECTRICAL CABLE REPLACEMENT PROCEDURES.

##### NOTE

The steps of this procedure are performed by divers in the cofferdam or by support personnel in the APU machinery room. Each step is annotated (DV) for diver performed steps or (TOP) for support personnel performed steps.



**CAUTION**

Ensure 10-inch DC plug (included in the kit) is brought into the cofferdam prior to commencing cable replacement. The DC plug provides a means of emergency support column seal if required.

**4-2.5.1 (TOP)** Ship's Force should have already disassembled the top of the training and retracting device to gain access to the secondary seal disk as shown in [Figure 4-9](#).

**4-2.5.2 (TOP)** Remove the support ring for the slip ring ([Figure 4-9](#)) from the secondary seal disk.

**4-2.5.3 (DV)** Confirm that the top hat cover with valve assembly is installed with the gasket on the support column flange ([Figure 4-7](#)). Check the vent valve shut.

**4-2.5.4 (TOP)** Install the closure plug assembly (Sheet 1 of NAVSEA Drawing [6699494](#) in [Appendix D](#)) onto the APU lifting screws in the APU machinery room. The closure plug is assembled to the boat winch and boat winch support in the NAVSEA APU kit. Support personnel should be able to set the boat winch support over the tops of the lifting screws as shown in the drawing.

**4-2.5.5 (TOP)** Loosen the closure plug stuffing tube to allow the plastic-coated boat winch wire to pass through the closure plug.

**4-2.5.6 (TOP)** Lift the closure plug out of the way and pull 3 feet of boat winch wire off the boat winch. Ensure that the rubber sleeve (item 29 of NAVSEA Drawing [6699494](#)) is still securely glued around the outside diameter of the closure plug before shackling the boat winch wire to the secondary seal disk.

**4-2.5.7 (TOP)** Thread a 3/8-inch eyebolt into the secondary seal disk and shackle the boat

winch wire to the eyebolt as shown in [Figure 4-10](#).

**CAUTION**

Water contacting the electrical cables can damage insulation and prevent proper electrical connection. Secondary seal temporary sealing caps will ensure water does not penetrate through any break in the secondary seal studs epoxy when the cable assembly is passed from the cofferdam to the surface.

**4-2.5.8 (TOP)** Install secondary seal temporary sealing caps (item 60 of NAVSEA [6699494](#)) onto each of three secondary seal studs as shown in NAVSEA [6699494](#).

**4-2.5.9 (DV)** Disconnect the nitrogen drying blow gun assembly from the quick disconnect at the end of the 100-foot nitrogen drying hose. See NAVSEA Drawing [6699497](#), Nitrogen Drying System, in [Appendix D](#).

**4-2.5.10 (DV)** Connect the nitrogen hose to the quick disconnect fitting on the top hat cover vent valve assembly. Open the vent valve.

**4-2.5.11 (TOP)** On the pier, disconnect the nitrogen drying hose from the nitrogen regulator and connect it to the quick disconnect on the vacuum pump assembly (item 7 on NAVSEA Drawing [6699494](#) in [Appendix D](#)).

**4-2.5.12 (TOP)** On the pier, operate the vacuum pump until personnel in the APU machinery room indicate that the secondary seal disk O-ring seal has broken and the secondary seal disk has dropped a short distance into the support column cavity. The disk seal normally breaks at about 20 inches Hg vacuum.

**4-2.5.13 (DV)** Shut the top hat vent valve and disconnect the nitrogen hose from the vent valve. Connect the hose to the quick discon-

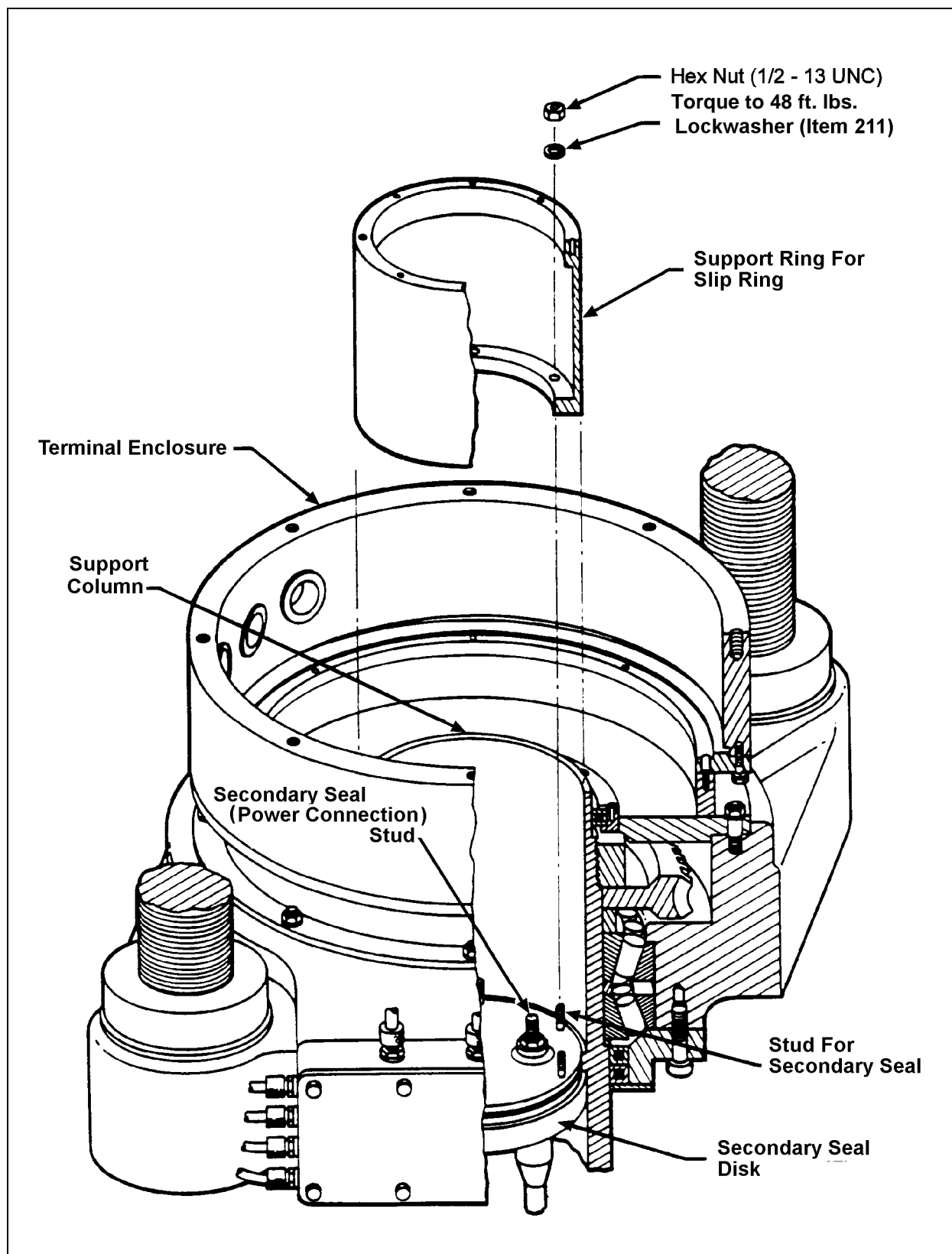


Figure 4-9. Access to Secondary Seal Disk.



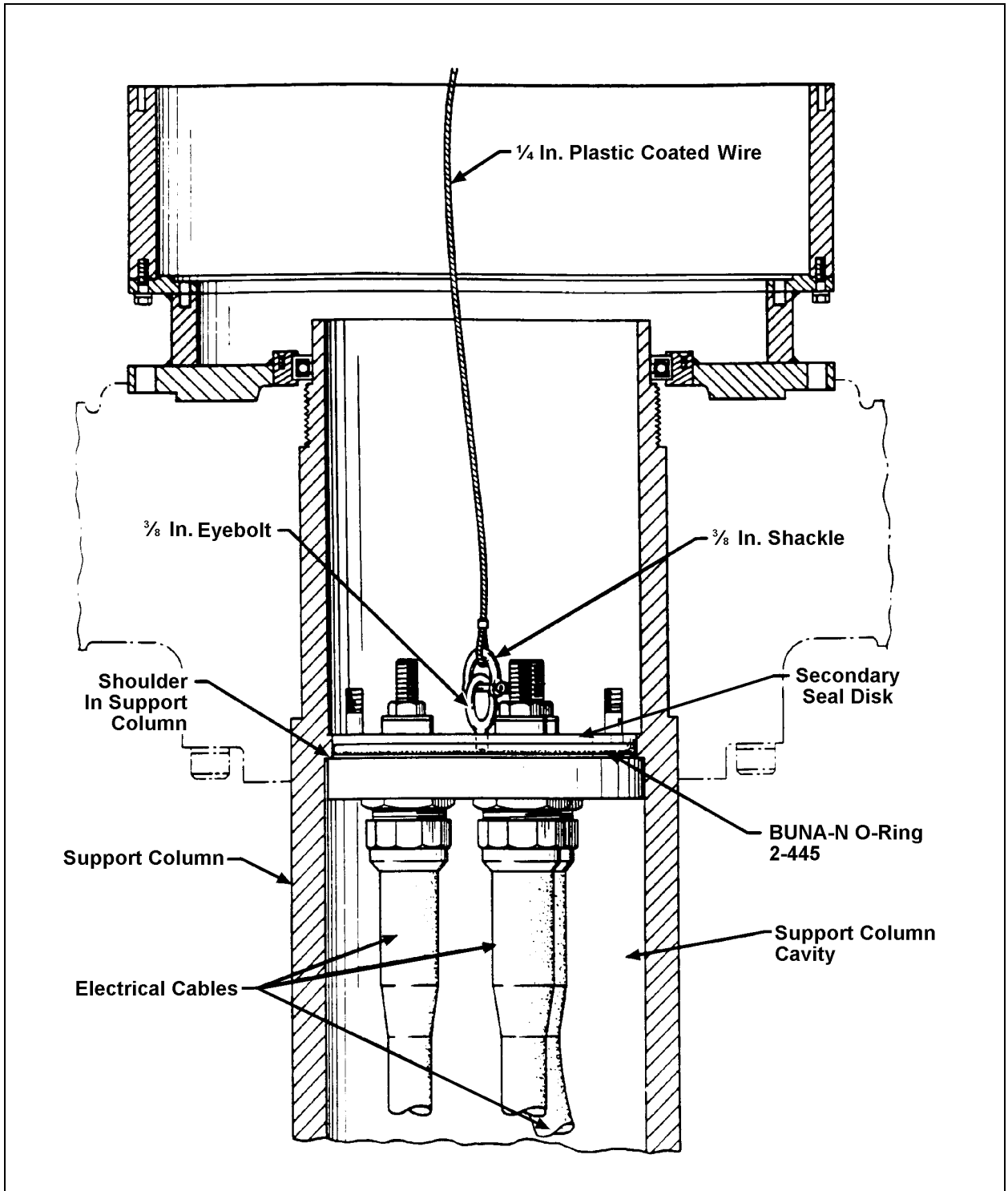


Figure 4-10. Attachment of Boat Winch Wire to Secondary Seal Disk.

nect valve on the nitrogen drying blow gun assembly.

**4-2.5.14 (TOP)** In the APU machinery room, slip the closure plug with rubber sleeve down the boat winch wire and into the top of the support column as shown on Sheet 1 of NAVSEA Drawing 6699494. Closure plug should be level and four inches below the top of the support column.

**4-2.5.15 (TOP)** Install the vent hose assembly (item 4 of NAVSEA 6699494) and seal hose assembly (item 6 of NAVSEA 6699494) into the closure plug. Shut the valve in the vent hose assembly. Using a SCUBA bottle with regulator, attach the BC inflation hose to the QD on the seal hose assembly and pressurize the seal to 120-150 psi.

#### CAUTION

Seal pressure must be maintained at 120-150 psi. Observe the seal hose assembly gauge for several minutes with the valve shut and the SCUBA bottle inflation hose disconnected to confirm that the closure plug seal is not leaking.

**4-2.5.16 (TOP)** Using the torque wrench and adapter (item 23 of NAVSEA 6699482 in Appendix D), tighten the closure plug set screws against the inside diameter of the support column to 60 ft-lbs. Torque the set screws using a diagonal (criss-cross) pattern.

**4-2.5.17 (TOP)** Tighten the closure plug stuffing tube around the plastic coated boat winch wire.

**4-2.5.18 (DV)** When the closure plug seal has been established, open the top hat vent valve to equalize support column pressure with cofferdam pressure.

**4-2.5.19 (TOP)** There should be no leaks around the closure plug and approximately 10

psi (cofferdam pressure) should show on the closure plug vent valve assembly gauge.

#### NOTE

Air escaping around the closure plug indicates an improper seal. Pressurize the inflatable seal (120-150 psi) until no air escapes around the closure plug. Do not exceed 150 psi. If increased inflation does not stop air leakage, it may be necessary to check the proper alignment of the closure plug or remove the closure plug, clean all surfaces, and reinstall the closure plug. Ensure that the top hat cover vent valve is shut prior to removing the closure plug.

**4-2.5.20 (DV)** Remove the top hat cover.

**4-2.5.21 (TOP, DV)** APU machinery room personnel lower the electrical cables and secondary seal disk using the boat winch while the divers guide the cables out of the support column. Personnel in the APU machinery room may need to loosen the stuffing tube slightly to lower the cables and secondary seal disk.

**4-2.5.22 (DV)** When the secondary seal disk emerges from the bottom of the support column, tie a small loop of line through the eyebolt in the secondary seal disk. Use the loop to hook on either of the support column fixture hoists to take over the weight of the cables and secondary seal disk from the boat winch wire.

**4-2.5.23 (DV)** Disconnect the boat winch wire from the secondary seal disk eyebolt. Use the hoist to yard and stay the secondary seal disk and cables to the surface via the crane.

**4-2.5.24 (DV)** Install the top hat cover and gasket on the support column flange ([Figure 4-7](#)). Shut the vent valve.

**4-2.5.25 (TOP)** On the pier, disconnect the electrical cables from the secondary seal disk. Using a 500 VDC megohmmeter, check the electrical insulation resistance of the secondary seal disk and each cable. All components must have a minimum of 10 megohm insulation resistance corrected for temperature in accordance with [Appendix A](#). If the secondary seal disk fails this check, it must be refurbished by the IMA in accordance with the NAVSEA secondary seal disk fabrication and assembly drawings in [Appendix B](#). Cables that fail this check must be replaced in accordance with the following steps.

**4-2.5.26 (TOP)** On the pier, install three cables that have passed the electrical insulation resistance (megger) check onto the secondary seal disk. Ensure that the APU motor end of each cable is labeled T1, T2, or T3 to correspond with the connection to the marked secondary seal disk. Replace the O-ring (2-445, item 13 of NAVSEA 6699482) on the secondary seal disk with a new, lubricated O-ring.

### CAUTION

Water contacting the electrical cables can damage insulation and prevent proper electrical connection.

**4-2.5.27 (TOP)** On the pier, install the Delrin sealing caps on the motor end of the cables and the secondary seal temporary sealing caps on the top end of each secondary seal stud.

**4-2.5.28 (TOP, DV)** Rig a downline to the support column fixture so that the cable assembly will run down to just below the bottom of the support column. Attach the cable assembly to the downline via the 3/8 inch eyebolt in the secondary seal disk. Lower the cable assembly to the support column.

### NOTE

Dry hands before working on the support column and cables.

**4-2.5.29 (DV)** Vent the top hat cover and confirm with topside that the closure plug seal is still holding. Remove the top hat cover from the bottom of the support column.

**4-2.5.30 (DV)** Attach the 1/4-inch boat winch wire (hanging in the support column) to the eyebolt in the secondary seal disk with the 3/8-inch shackle.

**4-2.5.31 (TOP)** Using the boat winch, pull the secondary seal disk and electrical cables up inside the support column until the top hat cover can be installed.

**4-2.5.32 (DV)** Install the top hat cover and gasket on the bottom flange of the support column.

**4-2.5.33 (DV)** Shut the vent valve in the top hat cover.

**4-2.5.34 (TOP)** Open the valve on the closure plug vent line and vent the support column until the pressure gauge indicates zero pressure to confirm the top hat cover is sealed.

**4-2.5.35 (TOP)** Vent the inflatable seal line on the closure plug until the gauge reads zero pressure.

**4-2.5.36 (TOP)** Loosen the stuffing tube on the closure plug assembly.

**4-2.5.37 (TOP)** Slide the closure plug up the boat winch wire.

**4-2.5.38 (TOP)** Use the boat winch to raise the secondary seal disk to its seated position against the shoulder in the support column (see figure 4-10). During the last few inches of the secondary seal disk's travel up the support column shaking the boat winch cable back and forth will help the secondary seal o-

ring slip into the smaller support column inside diameter at the secondary seal disk shoulder.

**4-2.5.39.** (DV, TOP) Open the vent valve in the top hat cover to pressurize the support column. Listen for air leaks at the secondary seal disk. No leaks are permitted.

**4-2.5.40.** (TOP) Remove the secondary seal temporary sealing caps from the secondary seal studs.

**4-2.5.41.** (TOP) Using a 500 VDC megohmmeter, measure the insulation resistance of all three cables at the secondary seal studs. A minimum of 3 megohms corrected for temperature in accordance with [Appendix A](#) is required.

**4-2.5.42.** (TOP) Slacken the boat winch wire. Disconnect the 3/8-inch shackle and the 1/4-inch wire from the eyebolt in the secondary seal disk.

**4-2.5.43.** (TOP) Install the support ring for the slip ring ([Figure 4-9](#)).

**4-2.5.44.** (TOP) Install the six 1/2-13 UNC hex nuts and lock washers on the studs for the secondary seal using a 3/4-inch socket and 12-inch extension. Torque nuts to 48 ft.-lbs. ([Figure 4-9](#)).

**4-2.5.45.** (TOP) Remove the eyebolt from the secondary seal disk.

**4-2.5.46.** (TOP) Have Ship's Force wait to reassemble the top part of the support column until after the APU motor has been installed. Then megger checks will ensure that no electrical problems exist at or below the secondary seal disk.

**4-2.5.47.** (DV) Remove the top hat cover from the support column.

**4-2.5.48.** (DV) Remove and replace O-ring (2-448, item 14 of NAVSEA 6699482) from the support column flange.

## 4-2.6 APU MOTOR REPLACEMENT.

**4-2.6.1** This procedure starts where the APU motor removal procedure (4-2.4) leaves off, that is, with an APU motor assembled to the fairing plate.

**4-2.6.2** Install the three sealing plugs ([Figure 4-6](#)) on the APU motor.

### CAUTION

Circulating water is necessary for proper motor cooling. Verify that the 18 vent and drain holes are unplugged before the APU motor is lowered into the water.

**4-2.6.3** Remove the 18 plastic plugs from the vent and drain holes (12 on the motor housing and 6 on the Kort nozzle). [Reference e](#) shows the location of all vent and drain holes.

**4-2.6.4.** Rig the APU motor in accordance with NAVSEA Drawing [6699592](#), APU Removal Rigging Plan, found in [Appendix D](#).

### NOTE

Use a spirit level to ensure that the APU motor flange is level as it hangs from the crane on the pier. This will ensure that the APU motor flange mates with the support column flange when the APU motor is transferred to the support column fixture.

**4-2.6.5.** With the crane, lift the APU motor a few inches to ensure that the APU motor flange is level both laterally and longitudinally.

**4-2.6.6.** Adjust the lift slings as necessary until the APU motor flange is level.

**4-2.6.7.** Ensure that the top hat cover has been removed from the support column flange.

**4-2.6.8.** Lubricate and install a new BUNA-N O-ring 2-448 on the support column flange.

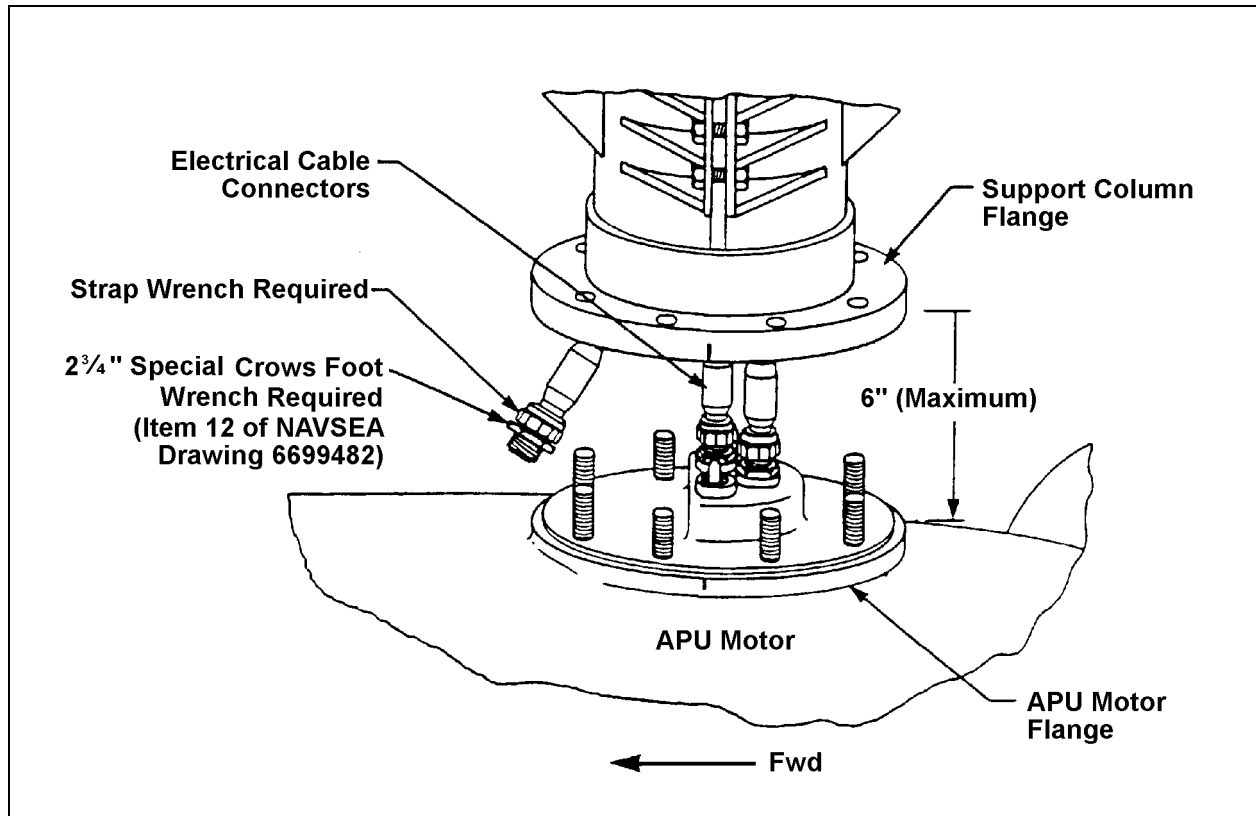
**4-2.6.9.** Yard and stay the APU motor to the support column fixture hoists. Raise the motor to a maximum of 6 inches below the support column flange.

**4-2.6.10.** Circulate dry nitrogen over all the electrical cable connections and APU motor terminals.

#### NOTE

Ensure that each electrical cable is matched to its corresponding terminal on the APU motor (T1-T1, T2-T2, and T3-T3).

**4-2.6.11** Connect the electrical cables to the APU motor ([Figure 4-11](#)).



**Figure 4-11. Electrical Cable Connection.**

**4-2.6.12** Raise the APU motor until the motor flange studs engage the support column flange and the two flanges meet.

**4-2.6.13** Request Ship's Force or repair activity personnel to conduct megger and continuity checks at the secondary seal disk. Megger check shall be done using a 500 VDC megohmmeter. Electrical insulation resistance shall be a minimum of 3 megohms when corrected for temperature in accordance with [Appendix A](#).

#### CAUTION

Improper alignment of the flange surfaces could dislodge the O-ring and prevent a proper seal when the flange nuts are tightened. Ensure that O-ring 2-448 has not been dislodged.

**4-2.6.14** Install the 1-8 UNC Nyloc stop nuts on the APU motor flange studs.

**NOTE**

A small gap will remain between the APU motor flange and the support column flange when the stop nuts are fastened snugly.

**4-2.6.15** Torque the stop nuts on the APU motor flange studs to 150 ft-lbs.

**4-2.6.16** Remove the lift slings, hoists, support column fixture, and all tools. Thoroughly check the inside of the APU storage compartment and cofferdam for loose gear. Return tools and equipment to the surface.

**4-2.6.17** Request that Ship's Force or repair activity personnel reassemble the top part of the support column assembly and confirm good megger checks at the power distribution panel.

**NOTE**

FFG 7 Class Advisory No. 02-97 revised MRC 13-4NMB-N to require a minimum of 10 Megohms insulation resistance in each phase of the APU motor 440 VAC circuit. 10 Megohms should be achievable after moisture introduced via waterborne cable replacement has been evaporated off by operating the system.

**4-2.6.18** Request Ship's Force or repair activity personnel to energize the retracting motor and raise the APU motor so that the fairing plate is within 2 or 3 inches of the shell plating

to verify proper alignment of the fairing plate in the hull opening.

**NOTE**

When the fairing plate is within 2 or 3 inches of the shell plating, divers shall verify that it can be raised all the way without contacting the shell plating. The fairing plate should be able to be raised all the way with a clearance of 1 inch  $\pm$  1/4 inch all the way around the hull opening.

**4-2.6.19** Raise the fairing plate to its fully retracted position when the divers have verified that it is properly aligned.

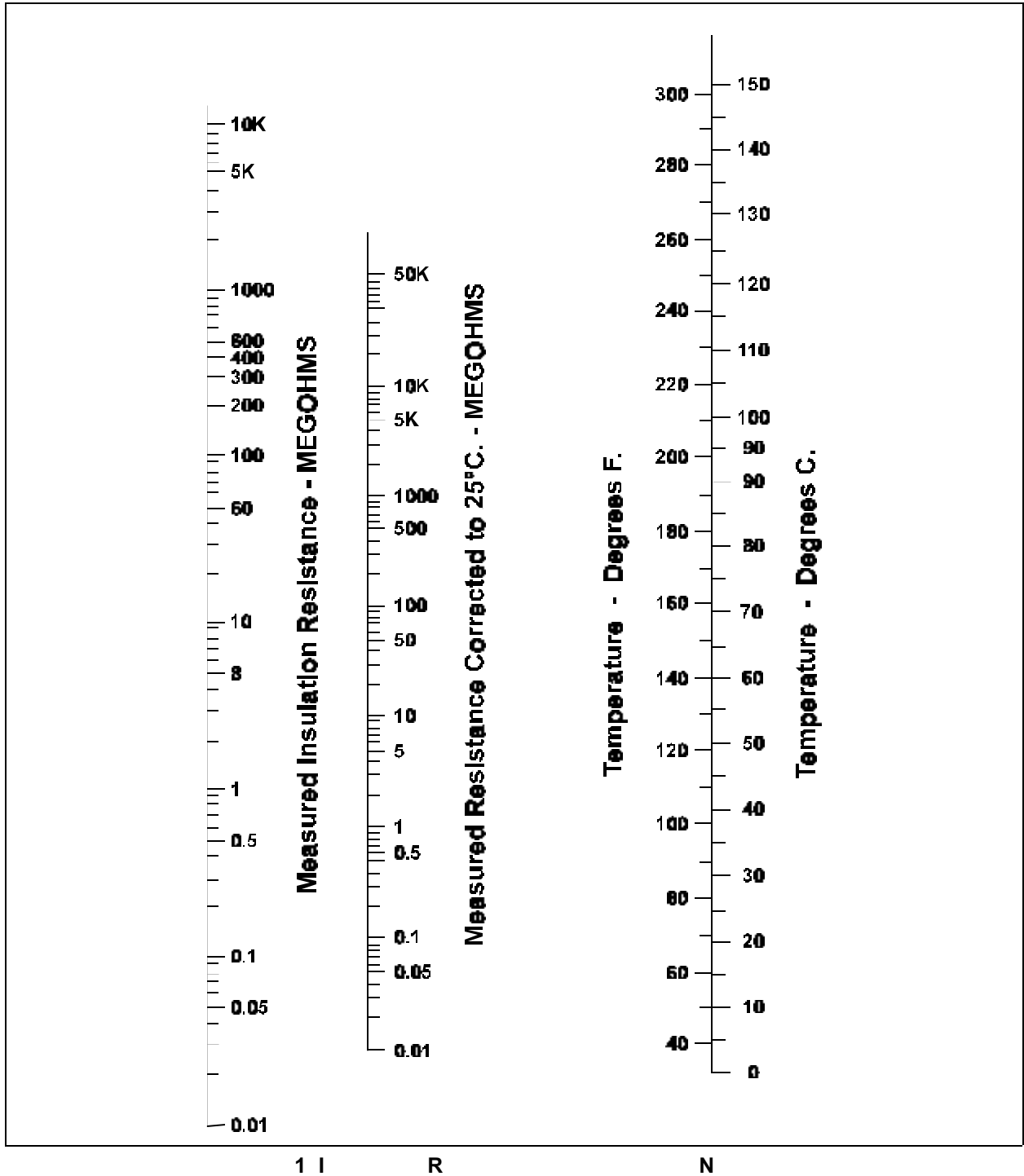
**4-2.6.20** Divers shall check and measure the fairness of the APU fairing plate with the outer shell plating. The forward edge of the plate should be flush (or recessed no more than 1/4 inch from the surface of the outer shell plating) and the after edge should be flush (or protruding no more than 1/4 inch from the surface of the outer shell plating).

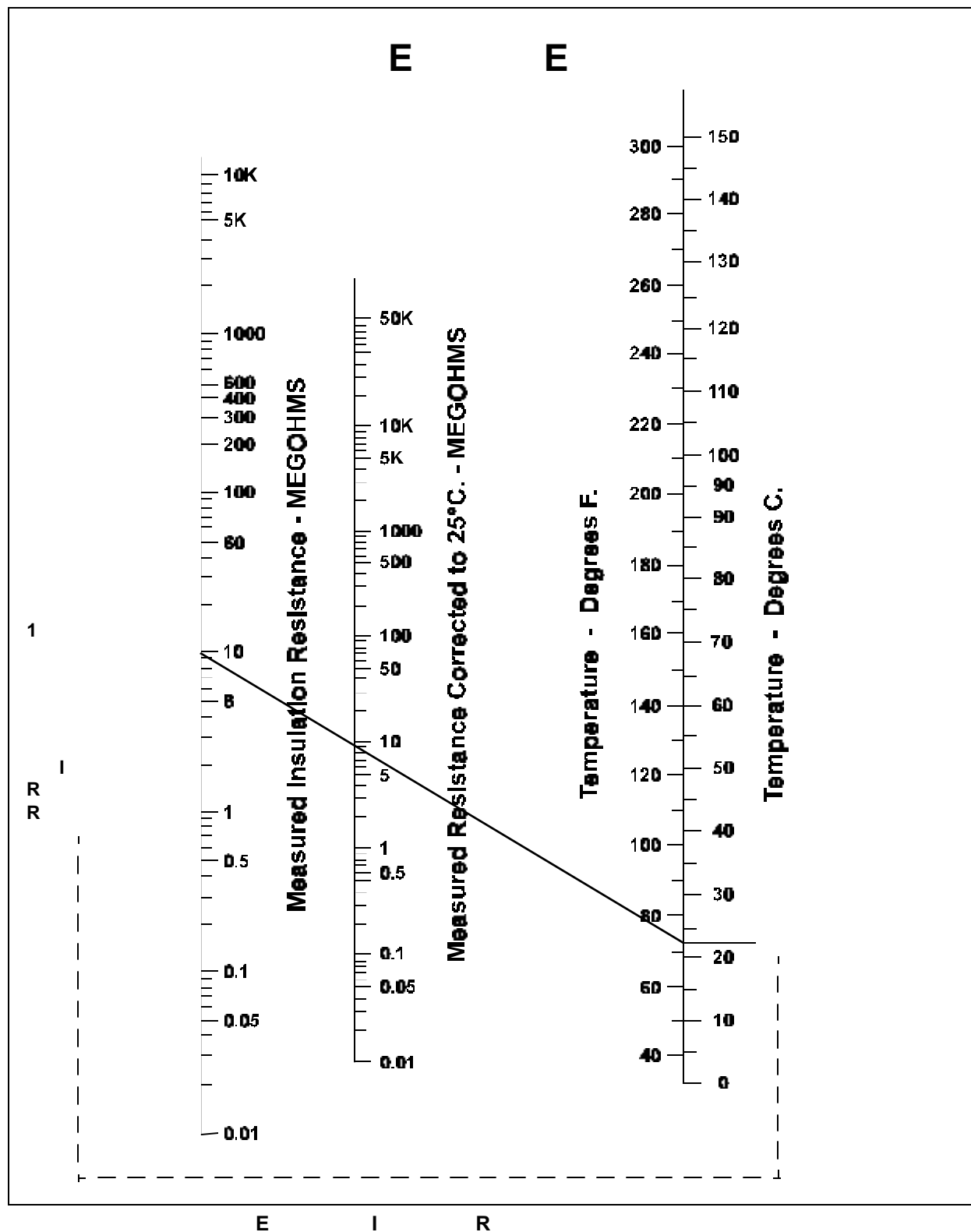
**4-2.6.21** Ensure that any air trapped in the free-flooding APU motor storage space is vented out. Some ships have vent valves for these spaces installed in the APU machinery room. If no vent valves are installed, the space may be vented in accordance with [reference a](#), paragraph 8-5a.

**4-2.6.22** Test operate the APU motor. If the propeller rotates in the wrong direction, correct by reversing any two of the three power leads from the power distribution panel.

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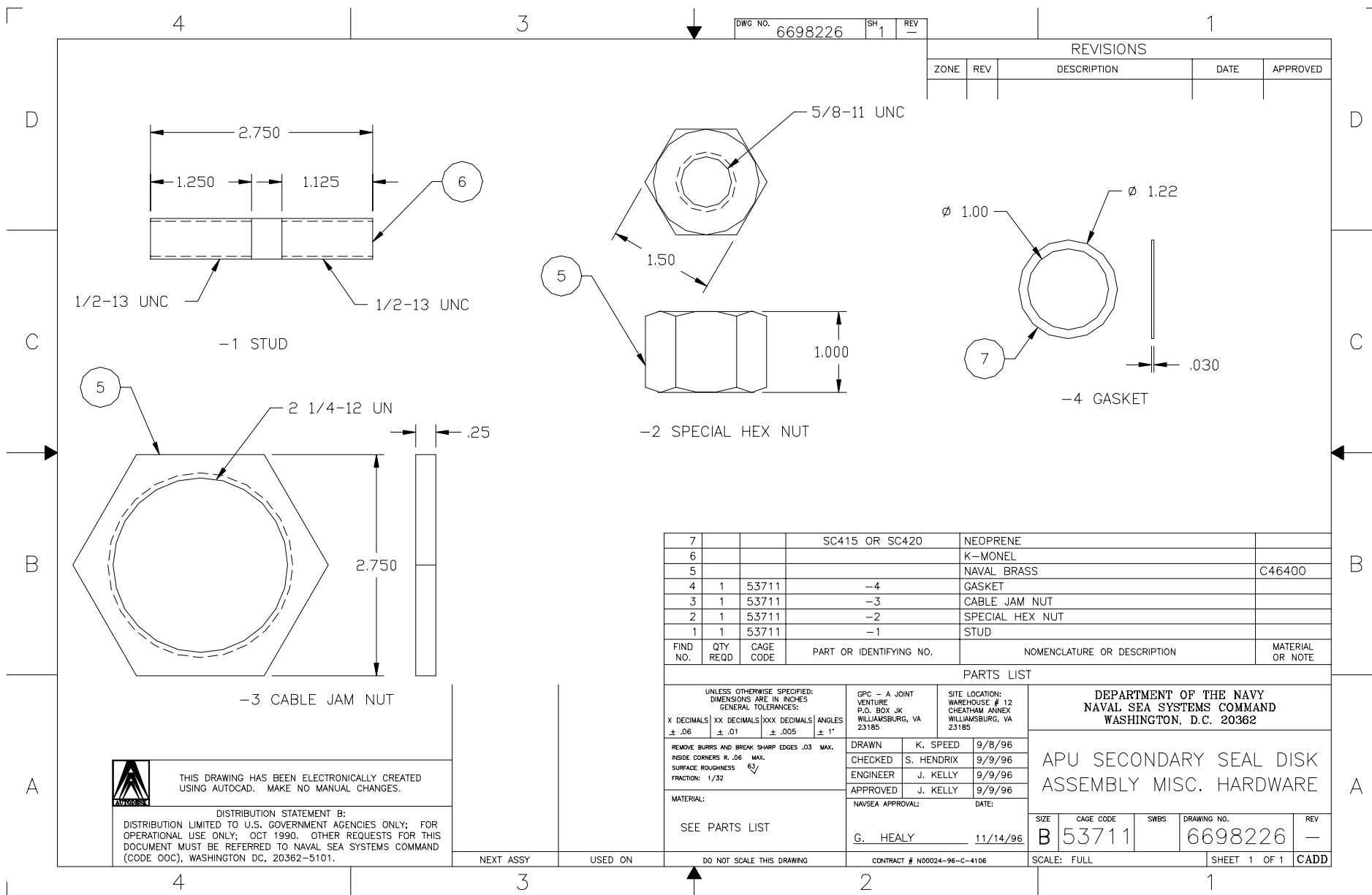
## **APPENDIX B**

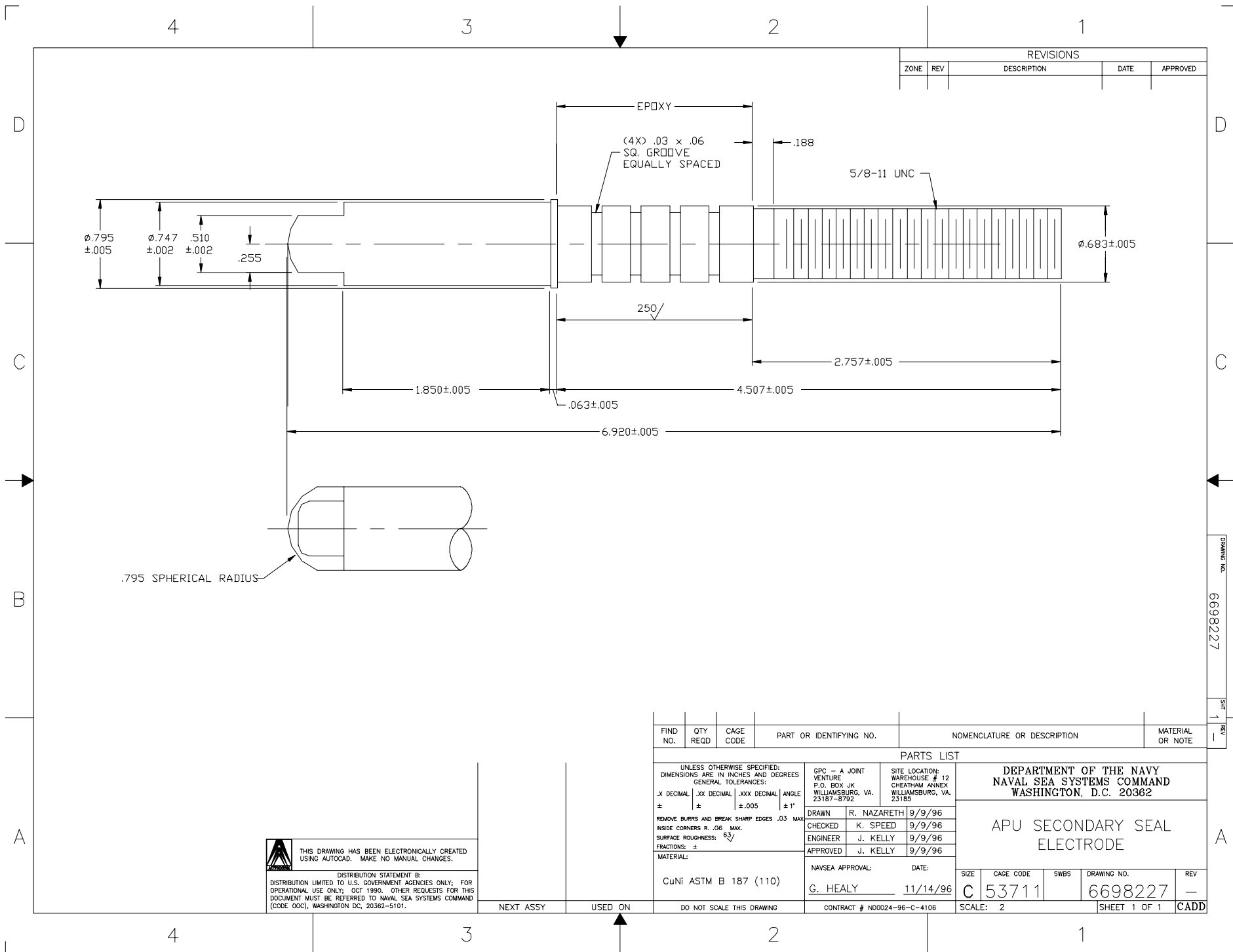
### **FABRICATION AND ASSEMBLY DRAWINGS FOR SECONDARY SEAL STUDS, SECONDARY SEAL DISK, AND SECONDARY SEAL ASSEMBLY**

#### **NAVSEA Number**


#### **Title**

<b>6698226 Rev-</b>	<b>APU Secondary Seal Disk Assembly Misc. Hardware</b>
<b>6698227 Rev-</b>	<b>APU Secondary Seal Electrode</b>
<b>6698228 Rev-</b>	<b>APU Secondary Seal Electrode Assembly</b>
<b>6698229 Rev-</b>	<b>APU Secondary Seal Disk Assembly</b>
<b>6699609 Rev-</b>	<b>APU Secondary Seal Disk</b>





REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

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FIND NO.	QTY REQD	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE
PARTS LIST					
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND DEGREES GENERAL TOLERANCES: .X DECIMAL   .XX DECIMAL   .XXX DECIMAL   ANGLE ±   ±   ±.005   ± 1°			GPC - A JOINT VENTURE P.O. BOX JK WILLIAMSBURG, VA. 23187-0702	SITE LOCATION: WAREHOUSE # 12 CHEATHAM ANNEX WILLIAMSBURG, VA. 23185	DEPARTMENT OF THE NAVY NAVAL SEA SYSTEMS COMMAND WASHINGTON, D.C. 20362
REMOVE BURRS AND BREAK SHARP EDGES .03 MAX. INSIDE CORNERS R. .06 MAX. SURFACE ROUGHNESS: 63/			DRAWN R. NAZARETH 9/9/96	CHECKED K. SPEED 9/9/96	APU SECONDARY SEAL ELECTRODE
FRACTIONS: ±			ENGINEER J. KELLY 9/9/96	APPROVED J. KELLY 9/9/96	
MATERIAL:  CuNi ASTM B 187 (110)			NAVSEA APPROVAL: G. HEALY	DATE: 11/14/96	
DO NOT SCALE THIS DRAWING				CONTRACT # N00024-96-C-4106	SCALE: 2
NEXT ASSY				USED ON	SHEET 1 OF 1
					CADD

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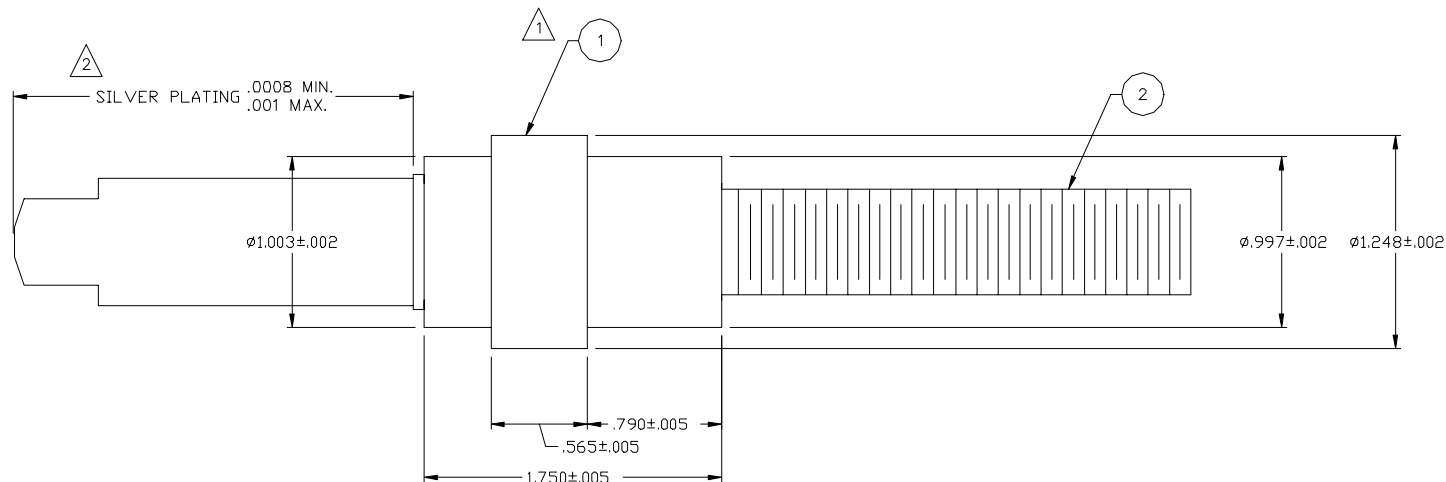
2

1

## NOTES:

1. PORTIONS FOR EPOXY RESIN ARE THREE PARTS  
C-4 RESIN TO TWO PARTS ACTIVATOR, "W".

2. SILVER PLATE ELECTRODE AFTER FINAL MACHINING OF EPOXY.



2	1	53711	6698227	SECONDARY SEAL ELECTRODE				
1	A/R	QJXX9		C-4 EPOXY ADHESIVE WITH ACTIVATOR, "W"	SEE NOTE1			
FIND NO.	QTY REQD	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE			
PARTS LIST								
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND DEGREES GENERAL TOLERANCES: .X DECIMAL   .XX DECIMAL   .XXX DECIMAL   ANGLE ±   ±   ±   ± REMOVE BURRS AND BREAK SHARP EDGES .03 MAX. INSIDE CORNERS R. .06 MAX. SURFACE ROUGHNESS: 63/ FRACTIONS: ± MATERIAL: SEE PARTS LIST			GPC - A JOINT VENTURE P.O. BOX JK WILLIAMSBURG, VA. 23187-8792 DRAWN R. NAZARETH 9/9/96 CHECKED K. SPEED 9/8/96 ENGINEER J. KELLY 9/9/96 APPROVED J. KELLY 9/9/96 NAVSEA APPROVAL: DATE: 11/14/96 G. HEALY			SITE LOCATION: WAREHOUSE # 12 CHEATHAM ANNEX WILLIAMSBURG, VA. 23185 DEPARTMENT OF THE NAVY NAVAL SEA SYSTEMS COMMAND WASHINGTON, D.C. 20362 APU SECONDARY SEAL ELECTRODE ASSEMBLY		
DISTRIBUTION STATEMENT B: DISTRIBUTION LIMITED TO U.S. GOVERNMENT AGENCIES ONLY; FOR OPERATIONAL USE ONLY; OCT 1990. OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO NAVAL SEA SYSTEMS COMMAND (CODE DDC), WASHINGTON DC, 20362-5101.			SIZE C 53711 SWBS 6698228 REV -					
NEXT ASSY			USED ON					
DO NOT SCALE THIS DRAWING			CONTRACT # N00024-96-C-4106					
SCALE: 2			SHEET 1 OF 1 CADD					

DRAWING NO.  
6698228

A

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3

DRAWING NO.

6698229

REV

1

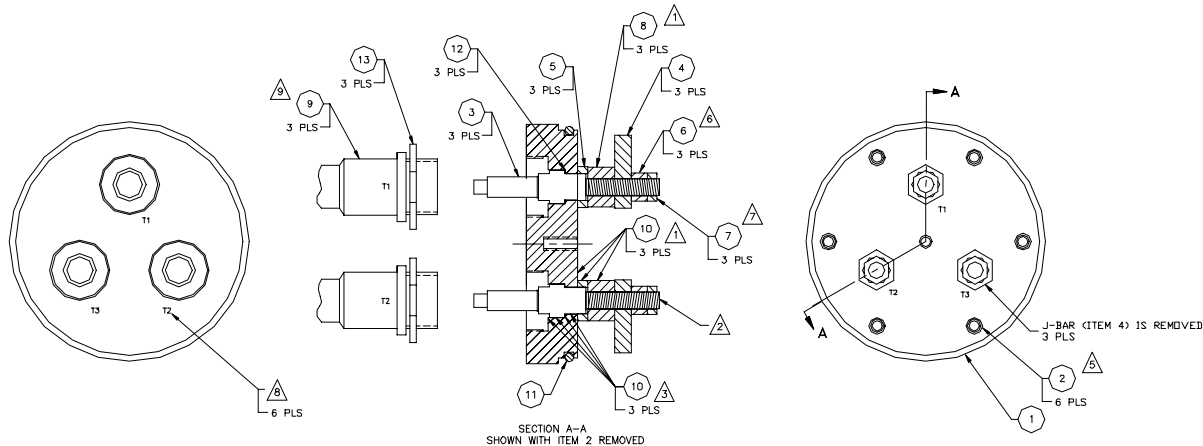
1

REVISIONS			
ZONE	REV	DESCRIPTION	DATE

## NOTES:

1. APPLY 3M SCOTCHCAST BRAND ELECTRICAL RESIN #5 TO FORM A MOISTURE SEAL. TORQUE SPECIAL HEX NUT (ITEM 8) TO 21 FT. LBS. BEFORE EPOXY HARDENS. DO NOT ALLOW EPOXY TO CONTACT THE TOP OF THE SPECIAL HEX NUT (ITEM 8).
2. DO NOT APPLY ANY THREAD LUBRICANT TO THE ELECTRODE.
3. APPLY ONE COAT OF THE 3M SCOTCHCAST BRAND ELECTRICAL RESIN #5 TO SURFACES SPECIFIED ON THE CIRCUMFERENCE OF THE ELECTRODE (ITEM 3) TO FORM A MOISTURE SEAL.
4. THE INSULATING WASHER (ITEM 5) IS MADE OF G-9 PLASTIC LAMINATED THERMOSETTING GLASS CLOTH, MELAMINE RESIN, WITH AN ID=1.000±.005 X O.D.=1.510±.005 AND .385±.005 THICK.
5. INSTALL STUDS (ITEM 2) WITH 1.125 LENGTH THREAD IN THE SECONDARY SEAL DISK (ITEM 1).

6. TORQUE HEAVY HEX NUT (ITEM 6) TO 78 FT LB.
7. TORQUE HEAVY JAM NUT (ITEM 7) TO 41 FT LB.
8. STAMP THE SECONDARY SEAL DISK (ITEM 1), T1, T2, T3 ON BOTH SIDES OF THE DISK ADJACENT TO THE RESPECTIVE ELECTRODES. USE 3/16 INCH HIGH MIN. CHARACTERS TO A DEPTH OF 1/32 INCH.
9. STAMP ONE APU CABLE T1. USE A 3/16 INCH HIGH MIN. CHARACTERS TO A DEPTH OF 1/32 IN. STAMP ANOTHER APU CABLE T2. USE A 3/16 INCH HIGH MIN. CHARACTERS TO A DEPTH OF 1/32 IN. STAMP THE THIRD APU CABLE T3. USE A 3/16 INCH HIGH MIN. CHARACTERS TO A DEPTH OF 1/32 IN.

SECTION A-A  
SHOWN WITH ITEM 2 REMOVED

13	3	53711	6698226-3	CABLE JAM NUT	
12	3	53711	6698226-4	CASKET	
11	1	02697	2-445	O-RING	BUNA-N
10	A/R	2V131		EPOXY, 3M, SCOTCHCAST BRAND ELECTRICAL RESIN #5 (5235)	SEE NOTES 1&3
9	3	90129	X8181-77	APU CABLE	
8	3	53711	6698226-2	NUT, HEX, SPECIAL	
7	3			NUT, JAM, HEAVY HEX, 5/8-11 UNC	
6	3			NUT, HEAVY HEX, 5/8-11 UNC	
5	3	40154		INSULATING WASHER	
4	3	01425	L5500754-1000 ITEM 46	J-BAR LEAD TERMINAL (EXISTING)	SEE NOTE 4
3	3	53711	6698228	APU SECONDARY SEAL ELECTRODE ASSEMBLY	
2	6	53711	6698226-1	STUD	SEE NOTE 5
1	1	53711	6698229	APU SECONDARY SEAL DISK	
FIND NO.	QTY	REQD	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
					MATERIAL OR NOTE

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND DECIMALS GENERAL TOLERANCES X DECIMAL   XX DECIMAL   XXX DECIMAL   ANGLE ±.06   ±.01   ±.005   ±.1° HOLE DRILLS AND REAM SHARP EDGES .02 MAX. HOLE CONES N. 25° MAX. SURFACE FINISHES: R3 FUNCTIONS: ±1/32				CPC - A JOINT VOLUME P.O. BOX 30 WILLIAMSBURG, VA 23187-8792		SITE LOCATION: WATERLOO # 12 OCEANVIEW AVENUE WILLIAMSBURG, VA 23185		DEPARTMENT OF THE NAVY NAVAL SEAL SYSTEMS COMMAND WASHINGTON, D.C. 20382	
DRAWN K. SPEED 9/8/96				CHECKED S. HENDRIX 9/9/96		ENGINEER J. KELLY 9/9/96		APU SECONDARY SEAL DISK ASSEMBLY	
APPROVED J. KELLY 9/9/96				DATE:					
MATERIALS:				NOTES: APPROVAL:					
SEE PARTS LIST				G. HEALY 11/14/96		SIZE D		CODE CODE 533711	
DO NOT SCALE THIS DRAWING				CONTRACT # N00024-96-C-4108		SHEET 1/2		DRAWING NO. 669820F 1	
						SHEET 1 OF 1		CADD	

DEPARTMENT OF THE NAVY  
NAVAL SEA SYSTEMS COMMAND  
WASHINGTON, D.C. 20362APU SECONDARY SEAL  
DISK ASSEMBLY

SIZE	CAGE CODE	SWMS	DRAWING NO.	REV
D	53711		6698229	—
SCALE: 1/2			SHEET 1 OF 1	
			CADD	

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**APPENDIX C**

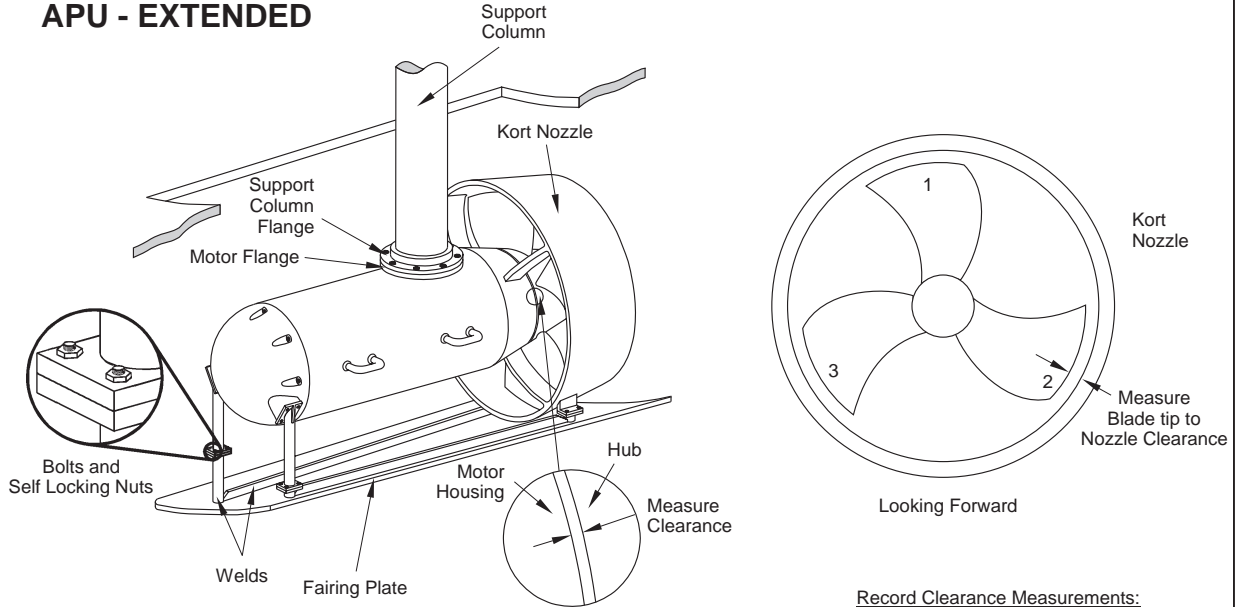
**DIVER'S INSPECTION FORM  
(AUXILIARY PROPULSION UNIT INSPECTION DATA)  
NAVSEA 4730/8**

# AUXILIARY PROPULSION UNIT INSPECTION DATA

USS	Hull No.	Location	Date
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Indicate Appropriate Unit: ☐ Stbd ☐ Port

## APU - EXTENDED



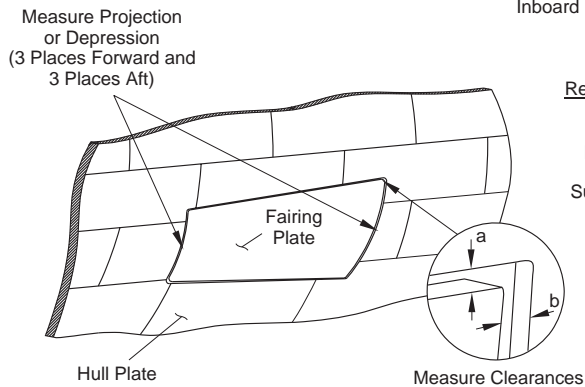
Record Clearance Measurements:

Prop Pulled Aft - Prop Pushed Fwd = Difference

Hub/Motor Housing		
-------------------	--	--

Blade Tip / Kort Nozzle		
-------------------------	--	--

## APU - RETRACTED



	Forward			AFT		
	Proj / Dep	a.	b.	Proj / Dep	a.	b.
Fairing Plate						
Outboard						
Mid Point						
Inboard						

Record:

	FR	PDR
Propeller		
Motor Housing		
Support Column		
Fairing Plate		

Condition Summary: \_\_\_\_\_

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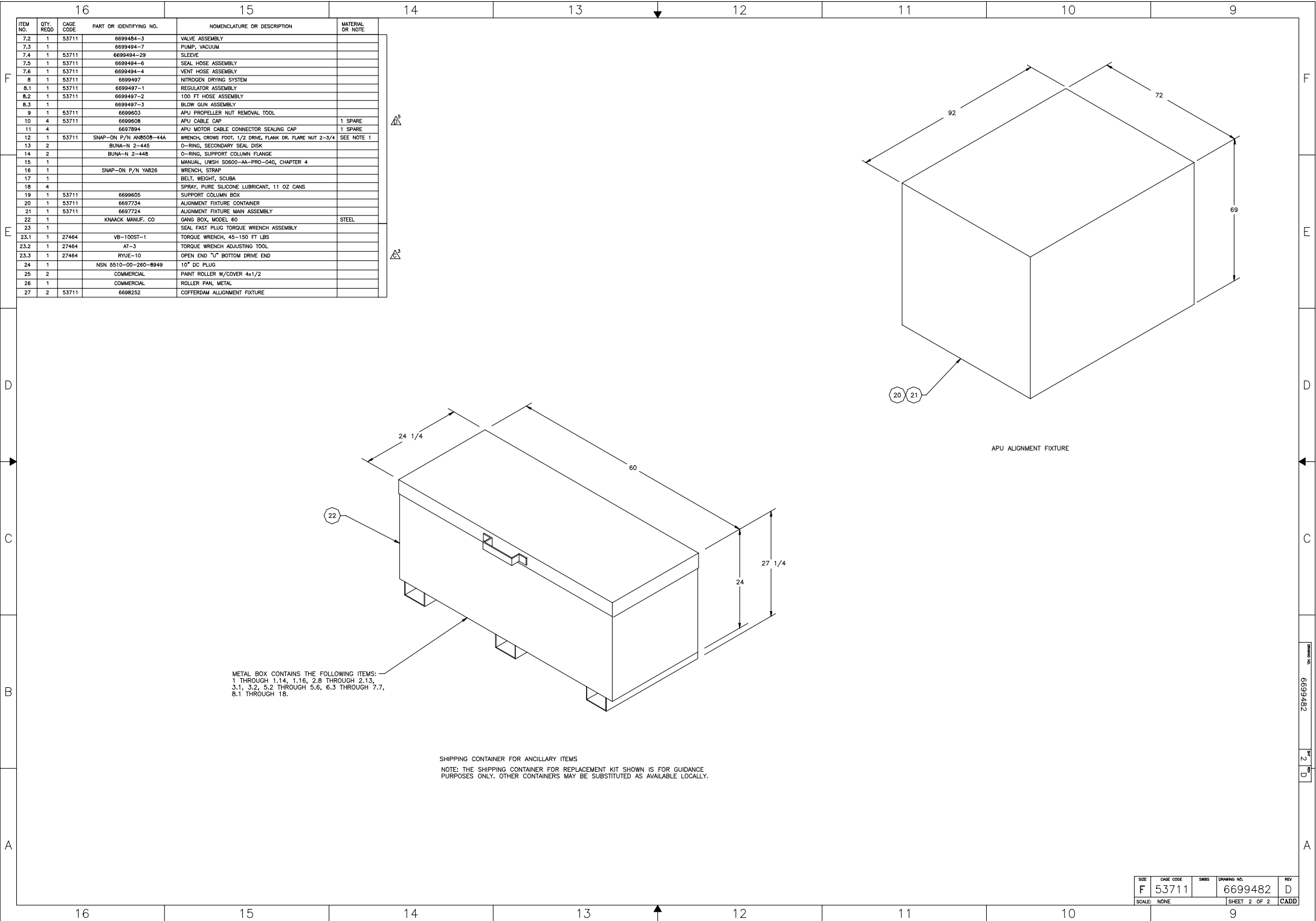
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**APPENDIX D**  
**NAVSEA APU KIT DRAWINGS**

<b>NAVSEA Number</b>	<b>Title</b>
<b>6699482 Rev D</b>	<b>FFG 7 APU Kit</b>
<b>6699592 Rev C</b>	<b>APU Removal Rigging Plan</b>
<b>6699484 Rev C</b>	<b>APU Cofferdam Main Assembly</b>
<b>6699576 Rev E</b>	<b>APU Cofferdam Rubber</b>
<b>6699494 Rev D</b>	<b>APU Secondary Seal Removal System</b>
<b>6699497 Rev A</b>	<b>Nitrogen Drying System</b>
<b>6699603 Rev -</b>	<b>APU Prop Nut Removal Tool</b>
<b>6697724 Rev -</b>	<b>Alignment Fixtures, Main Assembly</b>





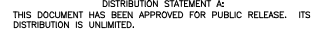
7.1.12	1	1CT71	6699494-28	PLUG, SEALFAST	
7.1.11	2		6699494-45	NUT, HEX, 3/8 - 16 UNC	
7.1.10	4		6699494-47	WASHER, FLAT, 3/8	
7.1.9	2		6699494-49	BOLT, HEX HEAD, 3/8 - 16 UNC X 1 LONG	
7.1.8	1		6699494-45	NUT, HEX, 1/2 - 9 UNC	
7.1.7	2		6699494-44	WASHER, FLAT, 7/8	
7.1.6	1		6699494-46	BOLT, HEX HEAD, 7/8 - 9 UNC X 1-1/2 LONG	
7.1.5	1	75535	6699494-43	EYEBOLT, 3/8 X 16 X 1 1/4 LONG	
7.1.4	1	75535	6699494-51	SHACKLE, SCREW PIN, 3/8	
7.1.3				ITEM DELETED	
7.1.2	1	53711	6699494-27	CABLE, VINYL COATED, AIRCRAFT, 20 FT LENGTH	
7.1.1	1	53711	6699494-8	BOAT WINCH SUPPORT	
7.1	1	53711	6699494-1	BOAT WINCH ASSEMBLY	
7	1	53711	6699494	APU SECONDARY SEAL REMOVAL SYSTEM	
6.5	16		6699492-17	NUT, 3/4 - 10 UNC	4 SPARES
6.4	16		6699492-16	WASHER, LOCK, 3/4	4 SPARES
6.3	28		6699492-15	WASHER, FLAT, 3/4 NOM.	4 SPARES
6.2	16		6699492-14	BOLT, HEX HEAD, 3/4 - 10 UNC X 3-1/2 LONG	4 SPARES
6.1	1	53711	6699492	SUPPORT COLUMN FIXTURE	
6	1		6699492	SUPPORT COLUMN FIXTURE ASSEMBLY AND DETAILS	
5.6	2		6699489-4	GASKET	1 SPARE
5.5	12		6699489-14	WASHER, LOCK, 1 NOM.	4 SPARES
5.4	20		6699489-12	WASHER, FLAT 1 NOM.	4 SPARES
5.3	12		6699489-13	NUT, 1 - 8 UNC	4 SPARES
5.2	12		6699489-11	BOLT, HEX HEAD, 1 - 8 UNC X 3-1/4 LONG	4 SPARES
5.1	1	53711	6699489-2	TOP HAT	
5	1	53711	6699489	TOP HAT ASSEMBLY	
4	1	53711	6699500	APU COFFERDAM STORAGE AND SHIPPING RACK	
3.2	120 FT		6699576-4	RUBBER, X 1 THICK	
3.1	2 GAL		6699576-10	ADHESIVE	
3		53711	6699576	APU COFFERDAM RUBBER	
2.13	1			HOSE, AIR 3/4 ID X 100FT	SEE NOTE 3
2.12	1	53711	6697713-17	COUPLING, UNIVERSAL, 3/4 NPT	
2.11	20	53711	6699484-16	BOLT, HEX HEAD, 1/2 - 13 UNC X 2 1/4 LONG	4 SPARES
2.10	75		6699484-12	NUT, 1/2 - 13 UNC	10 SPARES
2.9	140		6699484-11	WASHER, FLAT, 1/2	10 SPARES
2.8	55		6699484-10	BOLT, HEX HEAD, 1/2 - 13 UNC X 2-1/2 LONG FULLY THREADED	6 SPARES
2.7	2	53711	6699484-15	APU RIGGING STRONGBACK	
2.6	1	53711	6699484-6	PLATFORM WELDMENT	
2.5	2	53711	6699484-5	WALKWAY WELDMENT	
2.4	1	53711	6699484-4	OUTBOARD BULKHEAD	
2.3	1	53711	6699484-3	AFT BULKHEAD	
2.2	1	53711	6699484-2	FORWARD BULKHEAD	
2.1	1	53711	6699484-1	INBOARD BULKHEAD	
2	1	53711	6699484	APU COFFERDAM MAIN ASSEMBLY	
1.16	3	27353	6699592-26	HARRINGTON CF MODEL CHAIN HOIST, 3 TON	1 SPARE
1.15	4	ONDK5	6699592-13	SHACKLE, 1	
1.14	2	39428	6699592-15	SHACKLE, 1-1/4	
1.13	4	39428	6699592-14	SHACKLE, 3/4	
1.12	4	75575	6699592-11	SLING, 4 FT	
1.11	1	75575	6699592-9	SLING, 12 FT 4 INCHES LONG	
1.10	1	75575	6699592-10	SLING, 10 FT 9 INCHES LONG	
1.9	3	46964	6699592-8	LEVER HOIST, 4.5 TON CAP	1 SPARE
1.8	3	46964	6699592-7	LEVER HOIST, 3 TON CAP	1 SPARE
1.7	4	39428	6699592-24	MASTER LINK, 3/4	
1.6	8	39428	6699592-16	SHACKLE, 7/8	
1.5	1	53711	6699592-2	WIRE ROPE PENDANT, 3/4 X 396 (33 FT)	
1.4	1	53711	6699592-1	WIRE ROPE PENDANT, 3/4 X 444 (37 FT)	
1.3	1	53711	6699592-4	WIRE ROPE PENDANT, 5/8 X 312 (26 FT)	1 SPARE
1.2	1	53711	6699592-3	WIRE ROPE PENDANT, 5/8 X 384 (32 FT)	
1.1	2	53711	6699592-5	WIRE ROPE PENDANT, 1/2 X 480 (40 FT)	
1		53711	6699592	APU REMOVAL RIGGING	
ITEM NO.	QTY REQD	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE

PARTS LIST

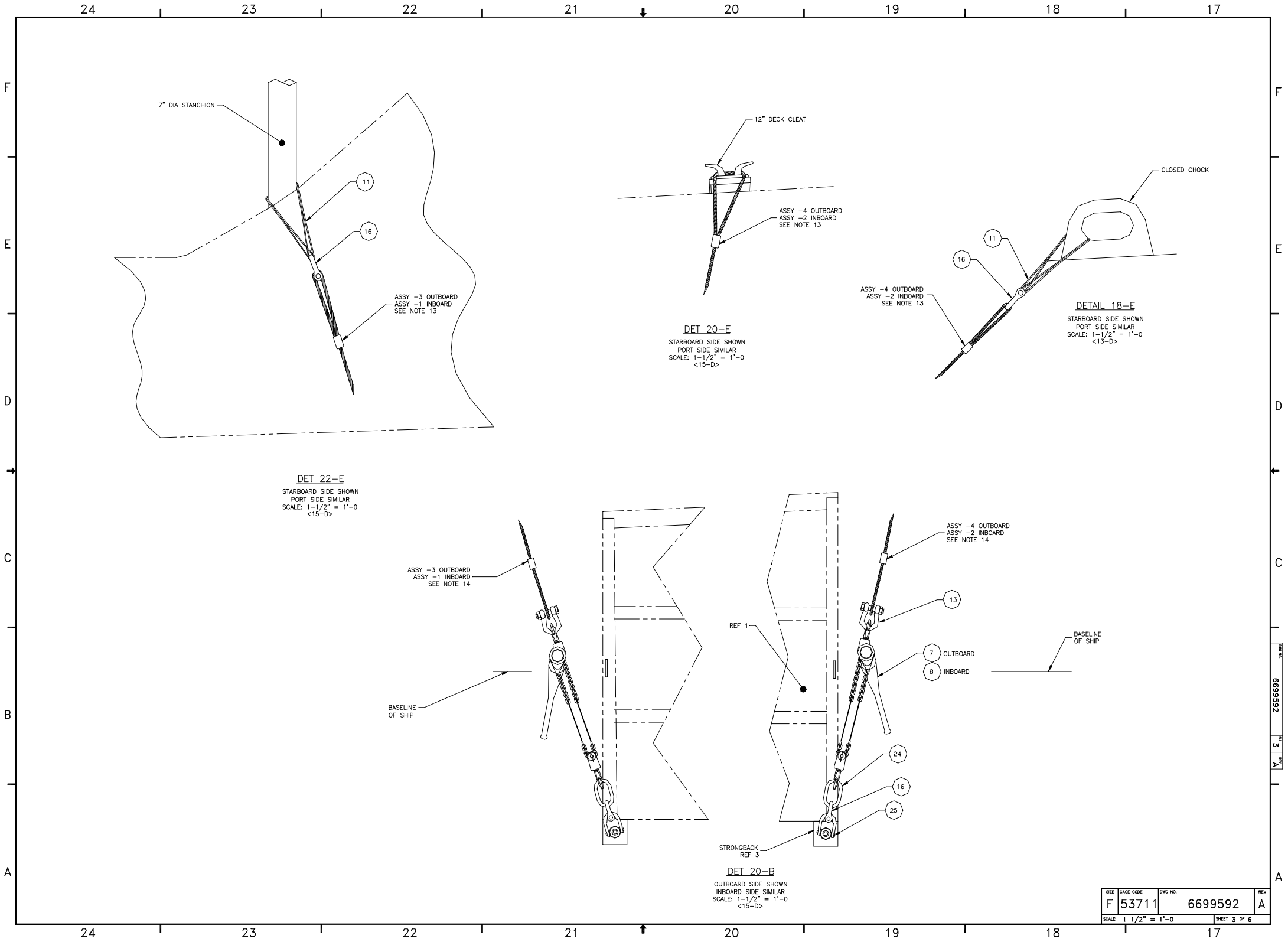
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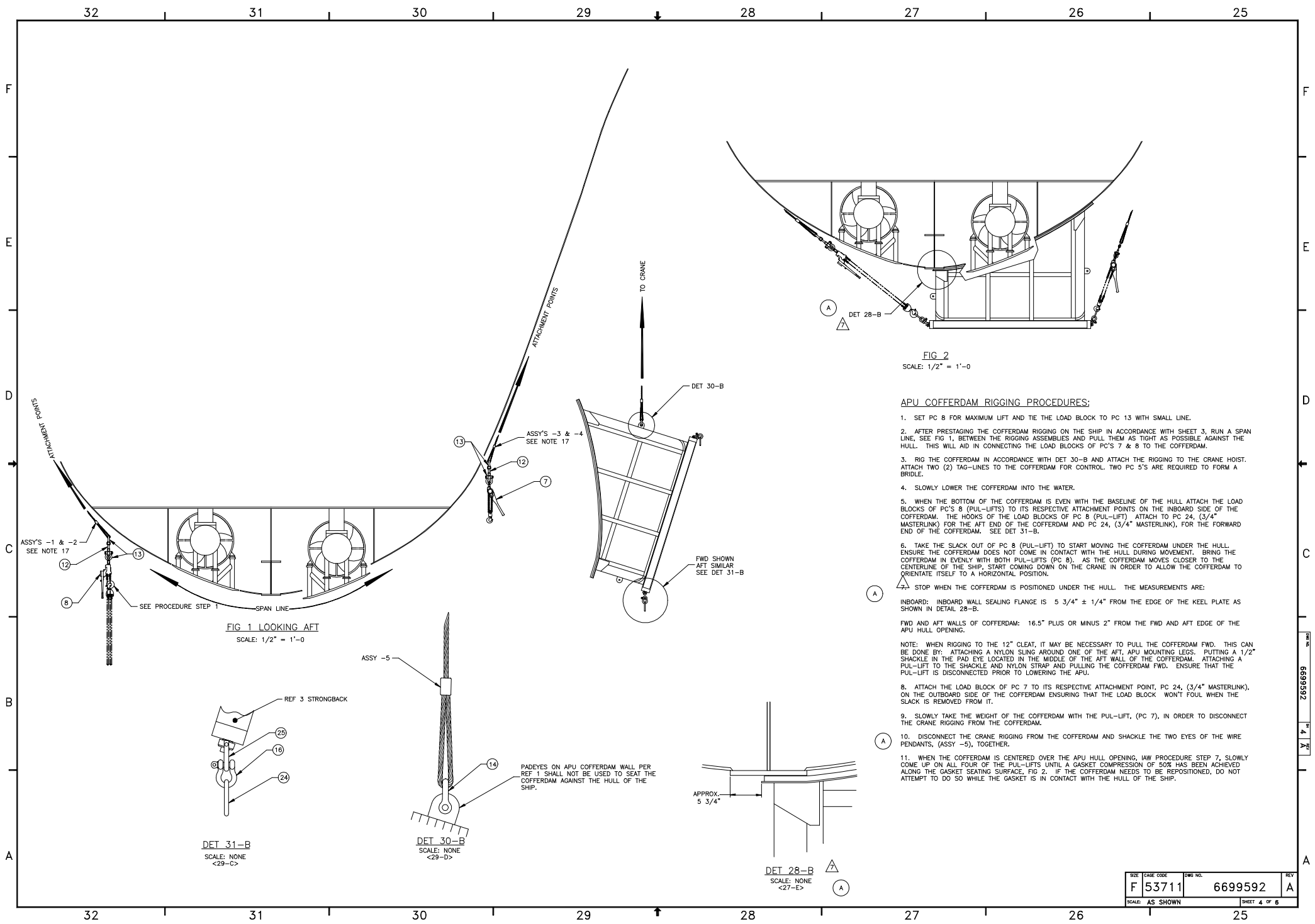
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7.3	1		6699494-7	PUMP, VACUUM	
7.4	1	53711	6699494-29	SLEEVE	
7.5	1	53711	6699494-6	SEAL HOSE ASSEMBLY	
7.6	1	53711	6699494-4	VENT HOSE ASSEMBLY	
8	1	53711	6699497	NITROGEN DRYING SYSTEM	
8.1	1	53711	6699497-1	REGULATOR ASSEMBLY	
8.2	1	53711	6699497-2	100 FT HOSE ASSEMBLY	
8.3	1		6699497-3	BLOW GUN ASSEMBLY	
9	1	53711	6699603	APU PROPELLER NUT REMOVAL TOOL	
10	4	53711	6699608	APU CABLE CAP	1 SPARE
11	4		6697894	APU MOTOR CABLE CONNECTOR SEALING CAP	1 SPARE
12	1	53711	SNAP-ON P/N AN8508-44A	WRENCH, CROWS FOOT, 1/2 DRIVE, FLANK DR. FLARE NUT 2-3/4	SEE NOTE 1
13	2		BUNA-N 2-445	O-RING, SECONDARY SEAL DISK	
14	2		BUNA-N 2-448	O-RING, SUPPORT COLUMN FLANGE	
15	1			MANUAL, UWSH S0600-AA-PRO-040, CHAPTER 4	
16	1		SNAP-ON P/N YA826	WRENCH, STRAP	
17	1			BELT, WEIGHT, SCUBA	
18	4			SPRAY, PURE SILICONE LUBRICANT, 11 OZ CANS	
19	1	53711	6699605	SUPPORT COLUMN BOX	
20	1	53711	6697734	ALIGNMENT FIXTURE CONTAINER	
21	1	53711	6697724	ALIGNMENT FIXTURE MAIN ASSEMBLY	
22	1		KNAACK MANUF. CO	GANG BOX, MODEL 60	STEEL
23	1			SEAL FAST PLUG TORQUE WRENCH ASSEMBLY	
23.1	1	27464	VB-100ST-1	TORQUE WRENCH, 45-150 FT LBS	
23.2	1	27464	AT-3	TORQUE WRENCH ADJUSTING TOOL	
23.3	1	27464	RYUE-10	OPEN END "U" BOTTOM DRIVE END	
24	1		NSN 5510-00-260-8949	10" DC PLUG	
25	2		COMMERCIAL	PAINT ROLLER W/COVER 4x1/2	
26	1		COMMERCIAL	ROLLER PAN, METAL	
27	2	53711	6698252	COFFERDAM ALIGNMENT FIXTURE	

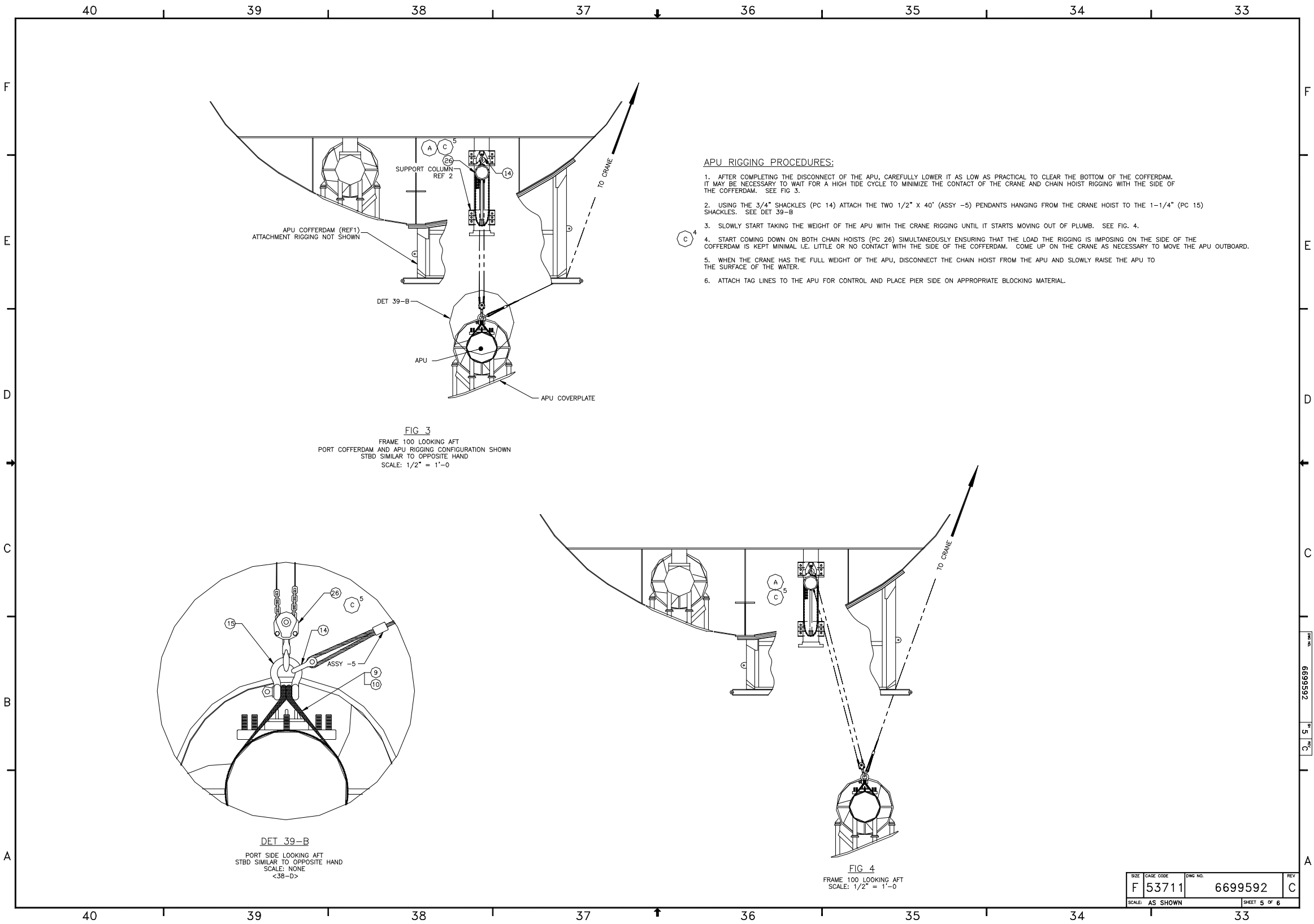


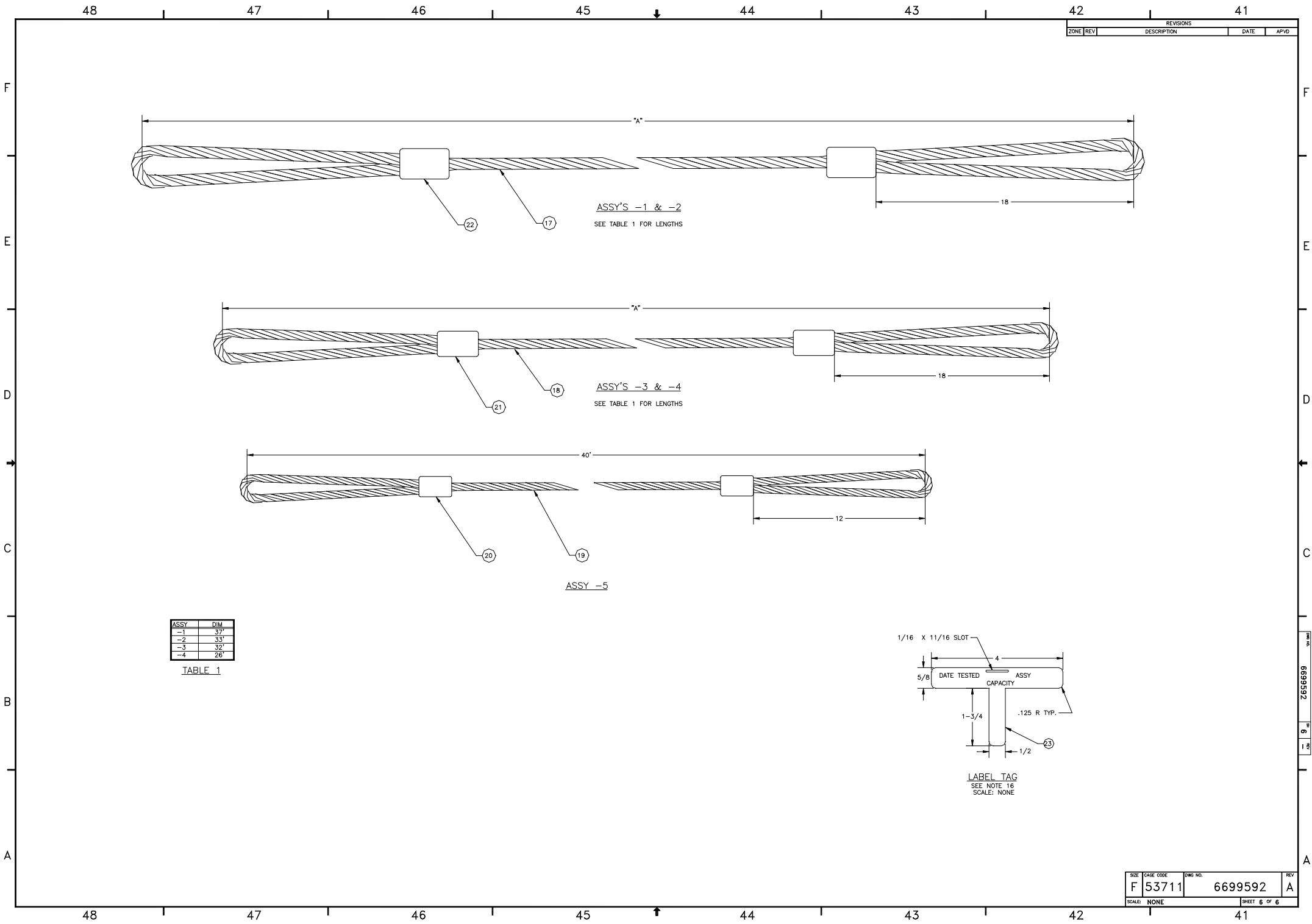


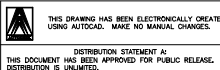


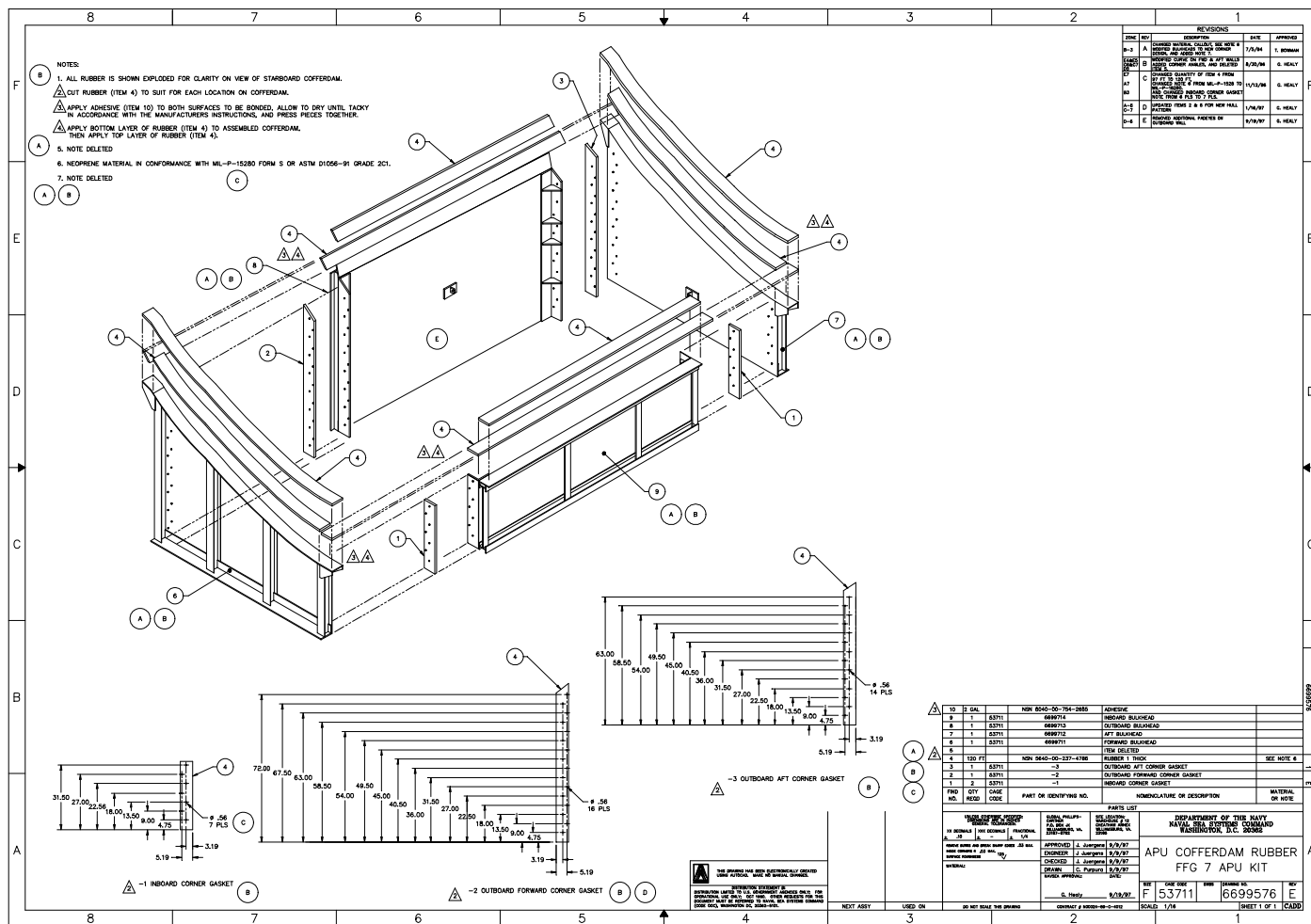


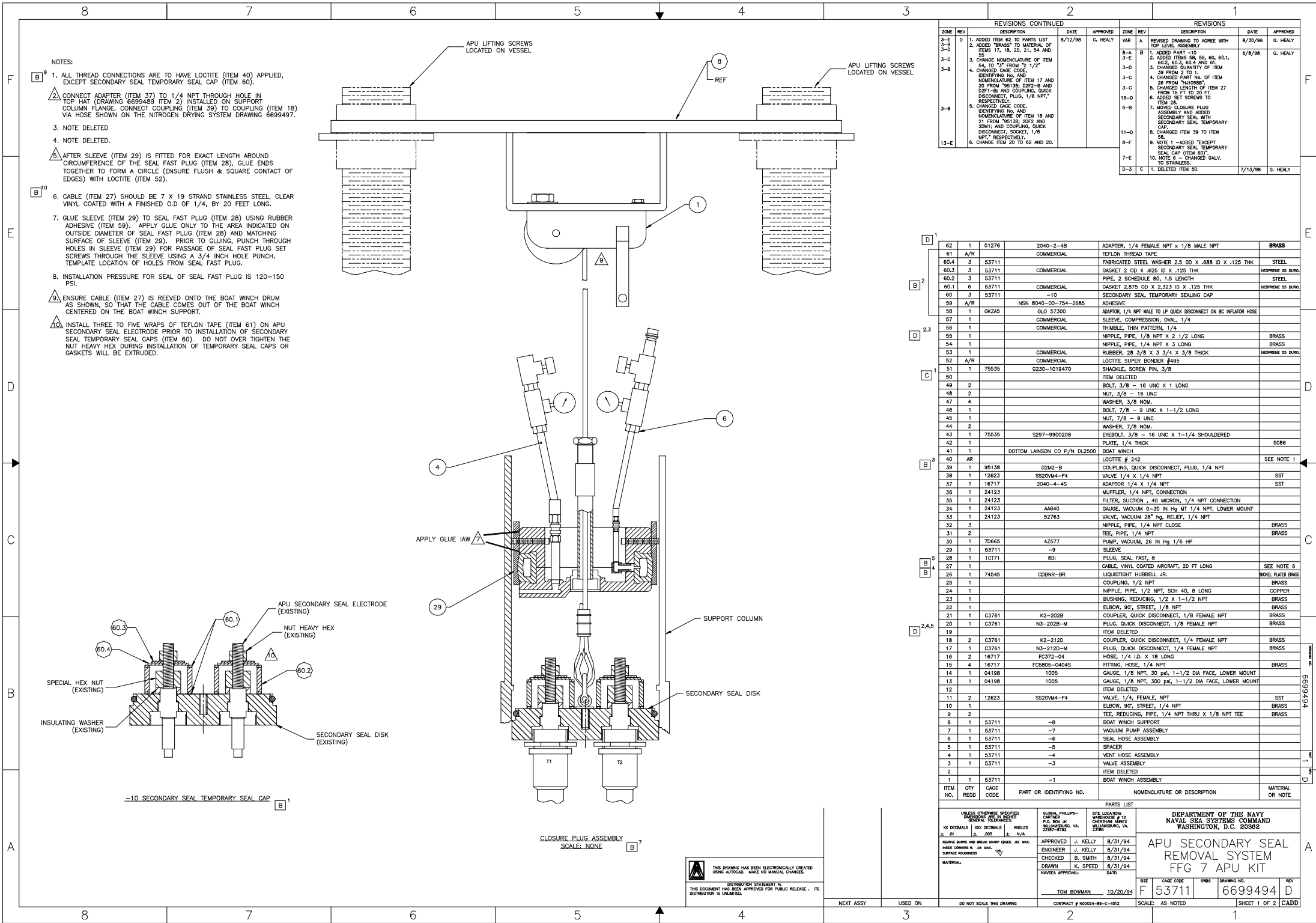


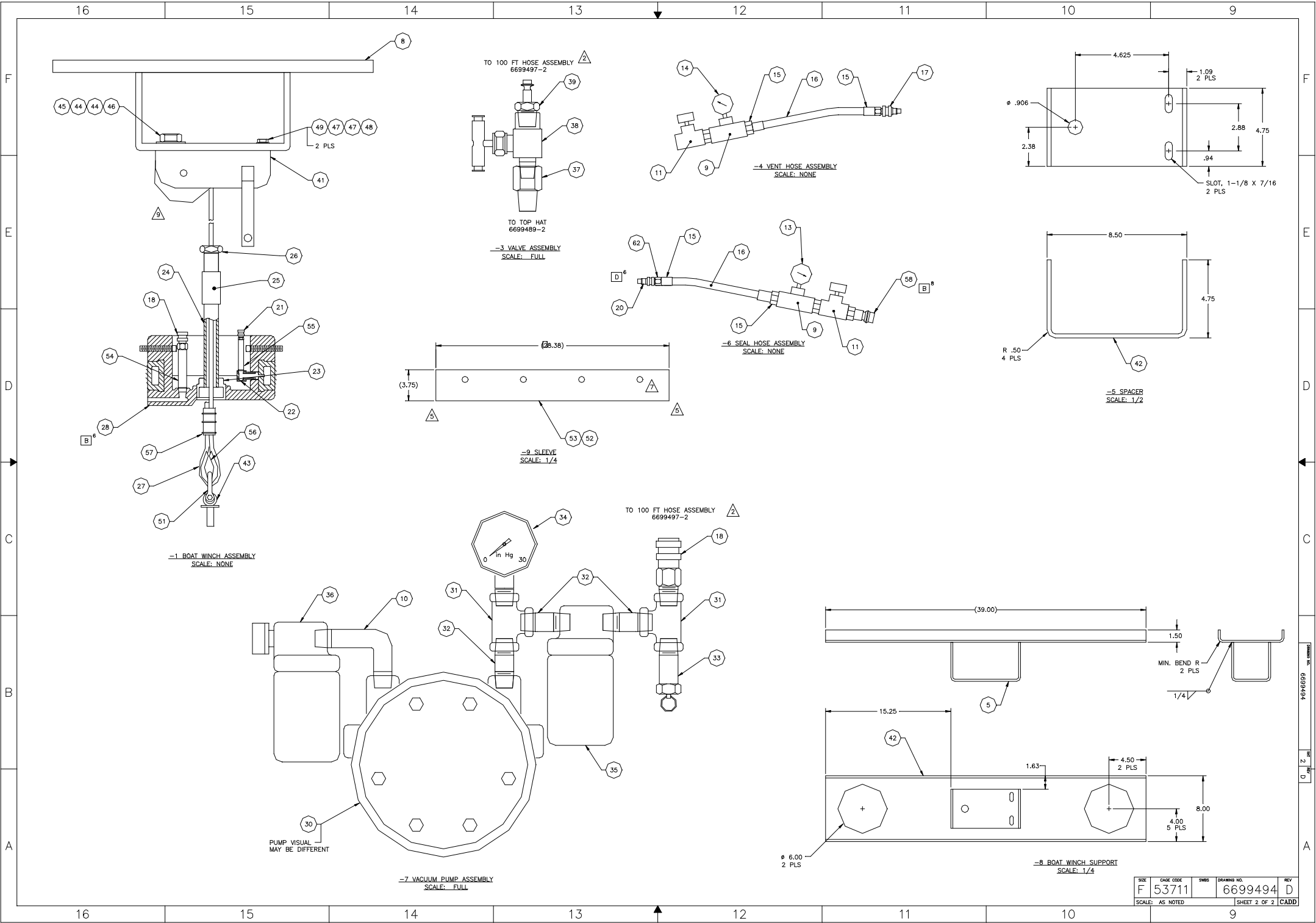


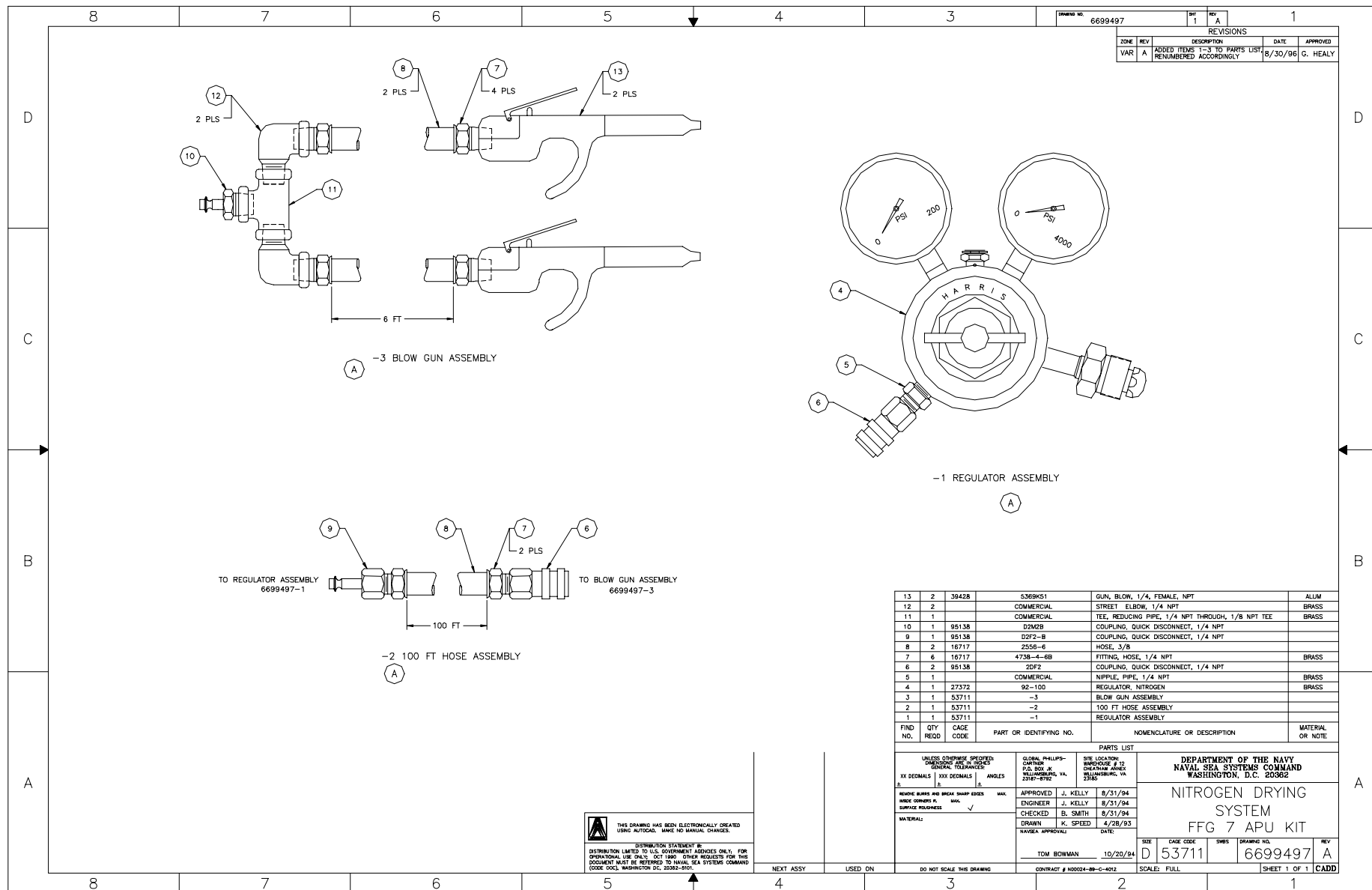




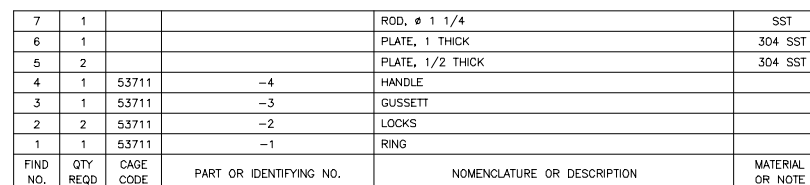
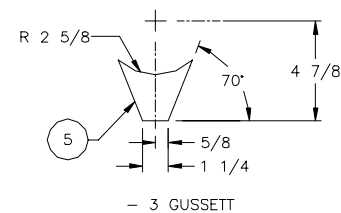












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MATERIAL:			SEE PARTS LIST GEOFF HEALY 8/29/96			SIZE C 53711 CASE CODE 0 SWBS			DRAWING NO 6699603		
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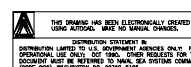
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SHEET 1 OF 1	CAD
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1. THIS DRAWING WAS FORMERLY TRACOR MARINE DRAWING 750032-503-361.
2. INTERPRET DRAWING IN ACCORDANCE WITH MIL-STD-100.
3. ALIGNMENT FIXTURE CONTAINERS ARE DETAILS ON NAVSEA DRAWING 6697734, APU ALIGNMENT FIXTURE CONTAINER ASSEMBLY AND DETAILS. FIG 7 APU KIT



6	1	NAYSEA DOW 6667732	STBD. JACKING FRAME ASSEMBLY.				
1		NAYSEA DOW 6667731	STBD. CLOSURE PLATE GAUGE ASSEMBLY				
4	1	NAYSEA DOW 6667730	STBD. HULL OPENING GAUGE ASSEMBLY				
3	1	NAYSEA DOW 6667729	PORT JACKING FRAME ASSEMBLY				
2	1	NAYSEA DOW 6667727	PORT CLOSURE PLATE GAUGE ASSEMBLY				
1	1	NAYSEA DOW 6667726	PORT HULL OPENING GAUGE ASSEMBLY				
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NAYSEA DOW AND NAYSEA DOW ENDS DRAW. NO. 80-10-4145 NAYSEA DOW ENDS ✓ FACTORY:			D. L. PETTON 4/17/76 CHECKED D. HICKOK 6/17/76 ENGINEER APPROVED		ALIGNMENT FIXTURES MAIN ASSEMBLY FFG 7 APIU KIT		
NAYSEA APPROVAL			DATE		SIZE		
N/A			GEOFF HEALY 7/3/96		F 53711		
					Q660 6697724		